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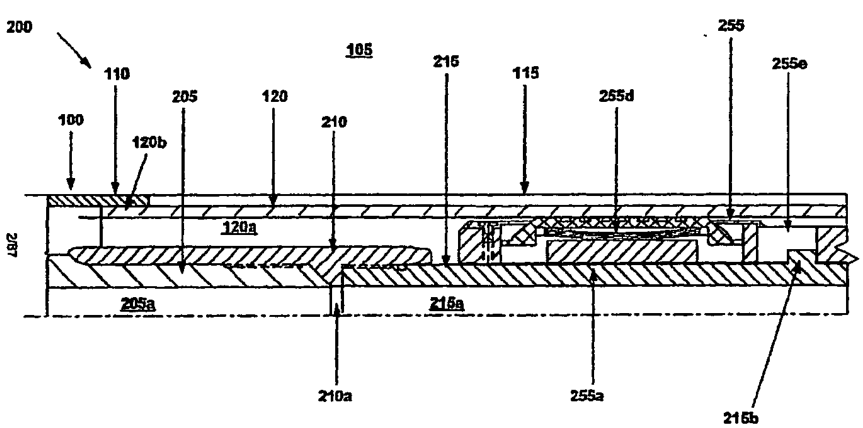
(54) Title: APPARATUS AND METHOD FOR RADIALLY EXPANDING A WELLBORE CASING USING AN EXPANSION SYSTEM




(57) Abstract: An apparatus and method for radially expanding a wellbore using an expansion system, the expansion system movable from a first small diameter configuration to a second larger diameter configuration.

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# APPARATUS AND METHOD FOR RADIALLY EXPANDING A WELLBORE CASING USING AN EXPANSION SYSTEM

## Cross Reference To Related Applications

[0001] This application claims the benefit of the filing date of US provisional patent application serial number 60/663,913, attorney docket number 25791.32, filed on March 21, 2005, the disclosure of which is incorporated herein by reference.

[0002] The present application is a continuation-in-part of U.S. utility patent application serial no. 10/488,574, attorney docket no. 25791.58.05, filed on 3/7/2004, which is the National Stage filing of PCT patent application serial no. PCT/US02/25608, attorney docket no. 25791.58.02, filed on August 13, 2002, which claimed the benefit of the filing date of U.S. provisional patent application serial no. 60/318,021, attorney docket no. 25791.58, filed on 9/7/2001, the disclosure of which is incorporated herein by reference.

[0003] This application is related to the following co-pending applications: (1) U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, which claims priority from provisional application 60/121,702, filed on 2/25/99, (3) U.S. Patent Number 6,823,937, which was filed as U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, which claims priority from provisional application 60/119,611, filed on 2/11/99, (4) U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (5) U.S. patent application serial no. 10/169,434, attorney docket no. 25791.10.04, filed on 7/1/02, which claims priority from provisional application 60/183,546, filed on 2/18/00, (6) U.S. patent no. 6,640,903 which was filed as U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (7) U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (8) U.S. patent number 6,575,240, which was filed as patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, which claims priority from provisional application 60/121,907, filed on 2/26/99, (9) U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (10) U.S. patent application serial no. 09/981,916, attorney docket no. 25791.18, filed on 10/18/01 as a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (11) U.S. patent number 6,604,763, which was filed as application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, which claims priority from provisional application 60/131,106, filed on 4/26/99, (12) U.S. patent application serial no. 10/030,593, attorney docket no. 25791.25.08, filed on 1/8/02, which claims priority from provisional application 60/146,203, filed on 7/29/99, (13) U.S. provisional patent application serial no. 60/143,039, attorney docket no. 25791.26, filed on 7/9/99, (14) U.S. patent application serial no. 10/111,982, attorney docket no. 25791.27.08, filed on 4/30/02, which claims priority from provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (15) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (16) U.S. provisional patent application serial no. 60/438,828, attorney docket no. 25791.31, filed on

1/9/03, (17) U.S. patent number 6,564,875, which was filed as application serial no. 09/679,907, attorney docket no. 25791.34.02, on 10/5/00, which claims priority from provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (18) U.S. patent application serial no. 10/089,419, filed on 3/27/02, attorney docket no. 25791.36.03, which claims priority from provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (19) U.S. patent application serial no. 09/679,906, filed on 10/5/00, attorney docket no. 25791.37.02, which claims priority from provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (20) U.S. patent application serial no. 10/303,992, filed on 11/22/02, attorney docket no. 25791.38.07, which claims priority from provisional patent application serial no. 60/212,359, attorney docket no. 25791.38, filed on 6/19/2000, (21) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (22) U.S. provisional patent application serial no. 60/455,051, attorney docket no. 25791.40, filed on 3/14/03, (23) PCT application US02/2477, filed on 6/26/02, attorney docket no. 25791.44.02, which claims priority from U.S. provisional patent application serial no. 60/303,711, attorney docket no. 25791.44, filed on 7/6/01, (24) U.S. patent application serial no. 10/311,412, filed on 12/12/02, attorney docket no. 25791.45.07, which claims priority from provisional patent application serial no. 60/221,443, attorney docket no. 25791.45, filed on 7/28/2000, (25) U.S. patent application serial no. 10/, filed on 12/18/02, attorney docket no. 25791.46.07, which claims priority from provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (26) U.S. patent application serial no. 10/322,947, filed on 1/22/03, attorney docket no. 25791.47.03, which claims priority from provisional patent application serial no. 60/233,638, attorney docket no. 25791.47, filed on 9/18/2000, (27) U.S. patent application serial no. 10/406,648, filed on 3/31/03, attorney docket no. 25791.48.06, which claims priority from provisional patent application serial no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, (28) PCT application US02/04353, filed on 2/14/02, attorney docket no. 25791.50.02, which claims priority from U.S. provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on 2/20/2001, (29) U.S. patent application serial no. 10/465,835, filed on 6/13/03, attorney docket no. 25791.51.06, which claims priority from provisional patent application serial no. 60/262,434, attorney docket no. 25791.51, filed on 1/17/2001, (30) U.S. patent application serial no. 10/465,831, filed on 6/13/03, attorney docket no. 25791.52.06, which claims priority from U.S. provisional patent application serial no. 60/259,486, attorney docket no. 25791.52, filed on 1/3/2001, (31) U.S. provisional patent application serial no. 60/452,303, filed on 3/5/03, attorney docket no. 25791.53, (32) U.S. patent number 6,470,966, which was filed as patent application serial number 09/850,093, filed on 5/7/01, attorney docket no. 25791.55, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (33) U.S. patent number 6,561,227, which was filed as patent application serial number 09/852,026 , filed on 5/9/01, attorney docket no. 25791.56, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (34) U.S. patent application serial number 09/852,027, filed on 5/9/01, attorney docket no. 25791.57, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (35) PCT Application US02/25608, attorney docket no. 25791.58.02, filed on 8/13/02, which claims priority from provisional application 60/318,021, filed on 9/7/01, attorney docket no. 25791.58, (36) PCT Application US02/24399, attorney docket no. 25791.59.02, filed on 8/1/02, which claims priority from U.S.

provisional patent application serial no. 60/313,453, attorney docket no. 25791.59, filed on 8/20/2001, (37) PCT Application US02/29856, attorney docket no. 25791.60.02, filed on 9/19/02, which claims priority from U.S. provisional patent application serial no. 60/326,886, attorney docket no. 25791.60, filed on 10/3/2001, (38) PCT Application US02/20256, attorney docket no. 25791.61.02, filed on 6/26/02, which claims priority from U.S. provisional patent application serial no. 60/303,740, attorney docket no. 25791.61, filed on 7/6/2001, (39) U.S. patent application serial no. 09/962,469, filed on 9/25/01, attorney docket no. 25791.62, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99, (40) U.S. patent application serial no. 09/962,470, filed on 9/25/01, attorney docket no. 25791.63, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99, (41) U.S. patent application serial no. 09/962,471, filed on 9/25/01, attorney docket no. 25791.64, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99, (42) U.S. patent application serial no. 09/962,467, filed on 9/25/01, attorney docket no. 25791.65, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99, (43) U.S. patent application serial no. 09/962,468, filed on 9/25/01, attorney docket no. 25791.66, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99, (44) PCT application US 02/25727, filed on 8/14/02, attorney docket no. 25791.67.03, which claims priority from U.S. provisional patent application serial no. 60/317,985, attorney docket no. 25791.67, filed on 9/6/2001, and U.S. provisional patent application serial no. 60/318,386, attorney docket no. 25791.67.02, filed on 9/10/2001, (45) PCT application US 02/39425, filed on 12/10/02, attorney docket no. 25791.68.02, which claims priority from U.S. provisional patent application serial no. 60/343,674 , attorney docket no. 25791.68, filed on 12/27/2001, (46) U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, (now U.S. Patent 6,634,431 which issued 10/21/2003), which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (47) U.S. utility patent application serial no. 10/516,467, attorney docket no. 25791.70, filed on 12/10/01, which is a continuation application of U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, (now U.S. Patent 6,634,431 which issued 10/21/2003), which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (48) PCT application US 03/00609, filed on 1/9/03, attorney docket no. 25791.71.02, which claims priority from U.S. provisional patent application serial no. 60/357,372 , attorney docket no. 25791.71, filed on 2/15/02, (49) U.S. patent application serial no. 10/074,703, attorney docket no. 25791.74, filed on 2/12/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (50) U.S. patent application serial no. 10/074,244, attorney docket no. 25791.75, filed on 2/12/02, which is a divisional of U.S.

patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (51) U.S. patent application serial no. 10/076,660, attorney docket no. 25791.76, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (52) U.S. patent application serial no. 10/076,661, attorney docket no. 25791.77, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (53) U.S. patent application serial no. 10/076,659, attorney docket no. 25791.78, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (54) U.S. patent application serial no. 10/078,928, attorney docket no. 25791.79, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (55) U.S. patent application serial no. 10/078,922, attorney docket no. 25791.80, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (56) U.S. patent application serial no. 10/078,921, attorney docket no. 25791.81, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (57) U.S. patent application serial no. 10/261,928, attorney docket no. 25791.82, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (58) U.S. patent application serial no. 10/079,276, attorney docket no. 25791.83, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (59) U.S. patent application serial no. 10/262,009, attorney docket no. 25791.84, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (60) U.S. patent application serial no. 10/092,481, attorney docket no. 25791.85, filed on 3/7/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (61) U.S. patent application serial no. 10/261,926, attorney docket no. 25791.86, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (62) PCT application US 02/36157, filed on 11/12/02, attorney docket no. 25791.87.02, which claims priority from U.S. provisional patent application serial no. 60/338,996, attorney docket no. 25791.87, filed on 11/12/01, (63) PCT application US 02/36267, filed on 11/12/02, attorney docket no. 25791.88.02, which claims priority from U.S. provisional patent application serial no. 60/339,013, attorney docket no. 25791.88, filed on 11/12/01, (64) PCT application US 03/11765, filed on 4/16/03, attorney docket no. 25791.89.02, which claims priority from U.S. provisional patent application serial no. 60/383,917, attorney docket no. 25791.89, filed on

5/29/02, (65) PCT application US 03/15020, filed on 5/12/03, attorney docket no. 25791.90.02, which claims priority from U.S. provisional patent application serial no. 60/391,703, attorney docket no. 25791.90, filed on 6/26/02, (66) PCT application US 02/39418, filed on 12/10/02, attorney docket no. 25791.92.02, which claims priority from U.S. provisional patent application serial no. 60/346,309, attorney docket no. 25791.92, filed on 1/7/02, (67) PCT application US 03/06544, filed on 3/4/03, attorney docket no. 25791.93.02, which claims priority from U.S. provisional patent application serial no. 60/372,048, attorney docket no. 25791.93, filed on 4/12/02, (68) U.S. patent application serial no. 10/331,718, attorney docket no. 25791.94, filed on 12/30/02, which is a divisional U.S. patent application serial no. 09/679,906, filed on 10/5/00, attorney docket no. 25791.37.02, which claims priority from provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (69) PCT application US 03/04837, filed on 2/29/03, attorney docket no. 25791.95.02, which claims priority from U.S. provisional patent application serial no. 60/363,829, attorney docket no. 25791.95, filed on 3/13/02, (70) U.S. patent application serial no. 10/261,927, attorney docket no. 25791.97, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (71) U.S. patent application serial no. 10/262,008, attorney docket no. 25791.98, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (72) U.S. patent application serial no. 10/261,925, attorney docket no. 25791.99, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (73) U.S. patent application serial no. 10/199,524, attorney docket no. 25791.100, filed on 7/19/02, which is a continuation of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (74) PCT application US 03/10144, filed on 3/28/03, attorney docket no. 25791.101.02, which claims priority from U.S. provisional patent application serial no. 60/372,632, attorney docket no. 25791.101, filed on 4/15/02, (75) U.S. provisional patent application serial no. 60/412,542, attorney docket no. 25791.102, filed on 9/20/02, (76) PCT application US 03/14153, filed on 5/6/03, attorney docket no. 25791.104.02, which claims priority from U.S. provisional patent application serial no. 60/380,147, attorney docket no. 25791.104, filed on 5/6/02, (77) PCT application US 03/19993, filed on 6/24/03, attorney docket no. 25791.106.02, which claims priority from U.S. provisional patent application serial no. 60/397,284, attorney docket no. 25791.106, filed on 7/19/02, (78) PCT application US 03/13787, filed on 5/5/03, attorney docket no. 25791.107.02, which claims priority from U.S. provisional patent application serial no. 60/387,486, attorney docket no. 25791.107, filed on 6/10/02, (79) PCT application US 03/18530, filed on 6/11/03, attorney docket no. 25791.108.02, which claims priority from U.S. provisional patent application serial no. 60/387,961, attorney docket no. 25791.108, filed on 6/12/02, (80) PCT application US 03/20694, filed on 7/1/03, attorney docket no. 25791.110.02, which claims priority from U.S. provisional patent application serial no. 60/398,061, attorney docket no. 25791.110, filed on 7/24/02, (81) PCT application US 03/20870, filed on 7/2/03, attorney docket no. 25791.111.02, which claims priority from U.S. provisional patent application serial no. 60/399,240, attorney docket no. 25791.111, filed on 7/29/02, (82) U.S. provisional patent application serial no. 60/412,487, attorney docket no. 25791.112, filed on 9/20/02, (83) U.S. provisional patent application serial no. 60/412,488, attorney docket no. 25791.114, filed on 9/20/02, (84) U.S. patent application serial no. 10/280,356, attorney docket no. 25791.115, filed on 10/25/02,

which is a continuation of U.S. patent number 6,470,966, which was filed as patent application serial number 09/850,093, filed on 5/7/01, attorney docket no. 25791.55, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (85) U.S. provisional patent application serial no. 60/412,177, attorney docket no. 25791.117, filed on 9/20/02, (86) U.S. provisional patent application serial no. 60/412,653, attorney docket no. 25791.118, filed on 9/20/02, (87) U.S. provisional patent application serial no. 60/405,610, attorney docket no. 25791.119, filed on 8/23/02, (88) U.S. provisional patent application serial no. 60/405,394, attorney docket no. 25791.120, filed on 8/23/02, (89) U.S. provisional patent application serial no. 60/412,544, attorney docket no. 25791.121, filed on 9/20/02, (90) PCT application US 03/24779, filed on 8/8/03, attorney docket no. 25791.125.02, which claims priority from U.S. provisional patent application serial no. 60/407,442, attorney docket no. 25791.125, filed on 8/30/02, (91) U.S. provisional patent application serial no. 60/423,363, attorney docket no. 25791.126, filed on 12/10/02, (92) U.S. provisional patent application serial no. 60/412,196, attorney docket no. 25791.127, filed on 9/20/02, (93) U.S. provisional patent application serial no. 60/412,187, attorney docket no. 25791.128, filed on 9/20/02, (94) U.S. provisional patent application serial no. 60/412,371, attorney docket no. 25791.129, filed on 9/20/02, (95) U.S. patent application serial no. 10/382,325, attorney docket no. 25791.145, filed on 3/5/03, which is a continuation of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (96) U.S. patent application serial no. 10/624,842, attorney docket no. 25791.151, filed on 7/22/03, which is a divisional of U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, which claims priority from provisional application 60/119,611, filed on 2/11/99, (97) U.S. provisional patent application serial no. 60/431,184, attorney docket no. 25791.157, filed on 12/5/02, (98) U.S. provisional patent application serial no. 60/448,526, attorney docket no. 25791.185, filed on 2/18/03, (99) U.S. provisional patent application serial no. 60/461,539, attorney docket no. 25791.186, filed on 4/9/03, (100) U.S. provisional patent application serial no. 60/462,750, attorney docket no. 25791.193, filed on 4/14/03, (101) U.S. provisional patent application serial no. 60/436,106, attorney docket no. 25791.200, filed on 12/23/02, (102) U.S. provisional patent application serial no. 60/442,942, attorney docket no. 25791.213, filed on 1/27/03, (103) U.S. provisional patent application serial no. 60/442,938, attorney docket no. 25791.225, filed on 1/27/03, (104) U.S. provisional patent application serial no. 60/418,687, attorney docket no. 25791.228, filed on 4/18/03, (105) U.S. provisional patent application serial no. 60/454,896, attorney docket no. 25791.236, filed on 3/14/03, (106) U.S. provisional patent application serial no. 60/450,504, attorney docket no. 25791.238, filed on 2/26/03, (107) U.S. provisional patent application serial no. 60/451,152, attorney docket no. 25791.239, filed on 3/9/03, (108) U.S. provisional patent application serial no. 60/455,124, attorney docket no. 25791.241, filed on 3/17/03, (109) U.S. provisional patent application serial no. 60/453,678, attorney docket no. 25791.253, filed on 3/11/03, (110) U.S. patent application serial no. 10/421,682, attorney docket no. 25791.256, filed on 4/23/03, which is a continuation of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99, (111) U.S. provisional patent application serial no. 60/457,965, attorney docket no. 25791.260, filed on 3/27/03, (112) U.S. provisional patent application serial no. 60/455,718, attorney docket no. 25791.262, filed on 3/18/03, (113) U.S. patent number 6,550,821, which was filed as patent application serial no. 09/811,734, filed on 3/19/01, (114) U.S. patent application serial no. 10/436,467, attorney docket no. 25791.268, filed on 5/12/03, which is a continuation of U.S.

patent number 6,604,763, which was filed as application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, which claims priority from provisional application 60/131,106, filed on 4/26/99, (115) U.S. provisional patent application serial no. 60/459,776, attorney docket no. 25791.270, filed on 4/2/03, (116) U.S. provisional patent application serial no. 60/461,094, attorney docket no. 25791.272, filed on 4/8/03, (117) U.S. provisional patent application serial no. 60/461,038, attorney docket no. 25791.273, filed on 4/7/03, (118) U.S. provisional patent application serial no. 60/463,586, attorney docket no. 25791.277, filed on 4/17/03, (119) U.S. provisional patent application serial no. 60/472,240, attorney docket no. 25791.286, filed on 5/20/03, (120) U.S. patent application serial no. 10/619,285, attorney docket no. 25791.292, filed on 7/14/03, which is a continuation-in-part of U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, (now U.S. Patent 6,634,431 which issued 10/21/2003), which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (121) U.S. utility patent application serial no. 10/418,688, attorney docket no. 25791.257, which was filed on 4/18/03, as a division of U.S. utility patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99; (122) PCT patent application serial no. PCT/US2004/06246, attor ney docket no. 25791.238.02, filed on 2/26/2004; (123) PCT patent application serial number PCT/US2004/08170, attorney docket number 25791.40.02, filed on 3/15/04; (124) PCT patent application serial number PCT/US2004/08171, attorney docket number 25791.236.02, filed on 3/15/04; (125) PCT patent application serial number PCT/US2004/08073, attorney docket number 25791.262.02, filed on 3/18/04; (126) PCT patent application serial number PCT/US2004/07711, attorney docket number 25791.253.02, filed on 3/11/2004; (127) PCT patent application serial number PCT/US2004/029025, attorney docket number 25791.260.02, filed on 3/26/2004; (128) PCT patent application serial number PCT/US2004/010317, attorney docket number 25791.270.02, filed on 4/2/2004; (129) PCT patent application serial number PCT/US2004/010712, attorney docket number 25791.272.02, filed on 4/6/2004; (130) PCT patent application serial number PCT/US2004/010762, attorney docket number 25791.273.02, filed on 4/6/2004; (131) PCT patent application serial number PCT/US2004/011973, attorney docket number 25791.277.02, filed on 4/15/2004; (132) U.S. provisional patent application serial number 60/495056, attorney docket number 25791.301, filed on 8/14/2003; (133) U.S. provisional patent application serial number 60/600679, attorney docket number 25791.194, filed on 8/11/2004; (134) PCT patent application serial number PCT/US2005/027318, attorney docket number 25791.329.02, filed on 7/29/2005; (135) PCT patent application serial number PCT/US2005/028936, attorney docket number 25791.338.02, filed on 8/12/2005; (136) PCT patent application serial number PCT/US2005/028669, attorney docket number 25791.194.02, filed on 8/11/2005; (137) PCT patent application serial number PCT/US2005/028453, attorney docket number 25791.371, filed on 8/11/2005; (138) PCT patent application serial number PCT/US2005/028641, attorney docket number 25791.372, filed on 8/11/2005; (139) PCT patent application serial number PCT/US2005/028819, attorney docket number 25791.373, filed on 8/11/2005; (140) PCT patent application serial number PCT/US2005/028446, attorney docket number 25791.374, filed on 8/11/2005; (141) PCT patent application serial number PCT/US2005/028642, attorney docket number 25791.375, filed on 8/11/2005; (142) PCT patent application serial number PCT/US2005/028451, attorney docket number 25791.376, filed on 8/11/2005, and (143). PCT patent application serial number PCT/US2005/028473, attorney docket number 25791.377, filed on 8/11/2005, (144) U.S. utility patent application serial number 10/546082, attorney docket number 25791.378, filed on 8/16/2005, (145) U.S. utility patent

application serial number 10/546076, attorney docket number 25791.379, filed on 8/16/2005, (146) U.S. utility patent application serial number 10/545936, attorney docket number 25791.380, filed on 8/16/2005, (147) U.S. utility patent application serial number 10/546079, attorney docket number 25791.381, filed on 8/16/2005 (148) U.S. utility patent application serial number 10/545941, attorney docket number 25791.382, filed on 8/16/2005, (149) U.S. utility patent application serial number 546078, attorney docket number 25791.383, filed on 8/16/2005, filed on 8/11/2005., (150) U.S. utility patent application serial number 10/545941, attorney docket number 25791.185.05, filed on 8/16/2005, (151) U.S. utility patent application serial number 11/249967, attorney docket number 25791.384, filed on 10/13//2005, (152) U.S. provisional patent application serial number 60/734302, attorney docket number 25791.24, filed on 11/7/2005, (153) U.S. provisional patent application serial number 60/725181, attorney docket number 25791.184, filed on 10/11/2005, (154) PCT patent application serial number PCT/US2005/023391, attorney docket number 25791.299.02 filed 6/29/2005 which claims priority from U.S. provisional patent application serial number 60/585370, attorney docket number 25791.299, filed on 7/2/2004, (155) U.S. provisional patent application serial number 60/721579, attorney docket number 25791.327, filed on 9/28/2005, (156) U.S. provisional patent application serial number 60/717391, attorney docket number 25791.214, filed on 9/15/2005, (157) U.S. provisional patent application serial number 60/702935, attorney docket number 25791.133, filed on 7/27/2005, (158) U.S. provisional patent application serial number 60/663913, attorney docket number 25791.32, filed on 3/21/2005, (159) U.S. provisional patent application serial number 60/652564, attorney docket number 25791.348, filed on 2/14/2005, (160) U.S. provisional patent application serial number 60/645840, attorney docket number 25791.324, filed on 1/21/2005, (161) PCT patent application serial number PCT/US2005/__________, attorney docket number 25791.326.02, filed on 11/29/2005 which claims priority from U.S. provisional patent application serial number 60/631703, attorney docket number 25791.326, filed on 11/30/2004, (162) U.S. provisional patent application serial number ___________, attorney docket number 25791.339, filed on 12/22/2005, (163) U.S. National Stage application serial no. 10/548934, attorney docket no. 25791.253.05, filed on 9/12/2005; (164) U.S. National Stage application serial no. 10/549410, attorney docket no. 25791.262.05, filed on 9/13/2005; (165) U.S. Provisional Patent Application No. 60/717391, attorney docket no. 25791.214 filed on 9/15/2005; (166) U.S. National Stage application serial no. 10/550906, attorney docket no. 25791.260.06, filed on 9/27/2005; (167) U.S. National Stage application serial no. 10/551880, attorney docket no. 25791.270.06, filed on 9/30/2005; (168) U.S. National Stage application serial no. 10/552253, attorney docket no. 25791.273.06, filed on 10/4/2005; (169) U.S. National Stage application serial no. 10/552790, attorney docket no. 25791.272.06, filed on 10/11/2005; (170) U.S. Provisional Patent Application No. 60/725181, attorney docket no. 25791.184 filed on 10/11/2005; (171) U.S. National Stage application serial no. 10/553094, attorney docket no. 25791.193.03, filed on 10/13/2005; (172) U.S. National Stage application serial no. 10/553566, attorney docket no. 25791.277.06, filed on 10/17/05; (173) PCT Patent Application No. PCT/US2006/__________, attorney docket no. 25791.324.02 filed on 1/20/06, and (174) PCT Patent Application No. PCT/US2006/__________, attorney docket no. 25791.348.02 filed on 2/9/06; (175) U.S. Utility Patent application serial no. __________________, attorney docket no. 25791.386, filed on 2/17/06, (176) U.S. National Stage application serial no. _________, attorney docket no. 25791.301.06, filed on ________, (177) U.S. National Stage application serial no. ____________, attorney docket no. 25791.137.04, filed on ___________, (178) U.S. National Stage application serial no. ____________, attorney docket no. 25791.215.06, filed on ___________.

## Background

[0004] This invention relates generally to oil and gas exploration, and in particular to forming and repairing wellbore casings to facilitate oil and gas exploration.

[0005] Conventionally, when a wellbore is created, a number of casings are installed in the borehole to prevent collapse of the borehole wall and to prevent undesired outflow of drilling fluid into the formation or inflow of fluid from the formation into the borehole. The borehole is drilled in intervals whereby a casing which is to be installed in a lower borehole interval is lowered through a previously installed casing of an upper borehole interval. As a consequence of this procedure the casing of the lower interval is of smaller diameter than the casing of the upper interval. Thus, the casings are in a nested arrangement with casing diameters decreasing in downward direction. Cement annuli are provided between the outer surfaces of the casings and the borehole wall to seal the casings from the borehole wall. As a consequence of this nested arrangement a relatively large borehole diameter is required at the upper part of the wellbore. Such a large borehole diameter involves increased costs due to heavy casing handling equipment, large drill bits and increased volumes of drilling fluid and drill cuttings. Moreover, increased drilling rig time is involved due to required cement pumping, cement hardening, required equipment changes due to large variations in hole diameters drilled in the course of the well, and the large volume of cuttings drilled and removed.

[0006] The present invention is directed to overcoming one or more of the limitations of the existing procedures for forming and/or repairing wellbore casings.

**Brief Description of the Drawings**

[0007] Fig. 1 is a cross-sectional view illustrating an embodiment of the placement of an apparatus for radially expanding a tubular member within a tubular member within a borehole within a subterranean formation.

[0008] Fig. 1a is a fragmentary cross-sectional view illustrating the placement of a section of the apparatus for radially expanding a tubular member within a tubular member within a borehole within a subterranean formation of Fig. 1.

[0009] Fig. 1b is a fragmentary cross-sectional view illustrating the placement of a section of the apparatus for radially expanding a tubular member within a tubular member within a borehole within a subterranean formation of Fig. 1.

[00010] Fig. 1c is a fragmentary cross-sectional view illustrating the placement of a section of the apparatus for radially expanding a tubular member within a tubular member within a borehole within a subterranean formation of Fig. 1.

[00011] Fig. 1d is a fragmentary cross-sectional view illustrating the placement of a section of the apparatus for radially expanding a tubular member within a tubular member within a borehole within a subterranean formation of Fig. 1.

[00012] Fig. 1e is a cross-sectional view illustrating an embodiment of the expansion cone support body of the apparatus of Figs. 1, 1a, 1b, 1c, and 1d.

[00013] Fig. 1f is a cross-sectional view illustrating an embodiment of the expansion cone support body of Fig. 1e.

[00014] Fig. 1g is a side view illustrating an embodiment of an expansion cone segment for use in the apparatus of Figs. 1, 1a, 1b, 1c, and 1d.

[00015] Fig. 1h is a front view illustrating an embodiment of the expansion cone segment of Fig. 1g.

[00016] Fig. 1i is a top view illustrating an embodiment of the expansion cone segment of Fig. 1g.

[00017] Fig. 1j is a top view illustrating an embodiment of interlocking expansion cone segments for use in the apparatus of Figs. 1, 1a, 1b, 1c, and 1d.

[00018] Fig. 1k is a top fragmentary circumferential view illustrating an embodiment of the coupling arrangement between the expansion cone segments and the split ring collar for use in the apparatus of Figs. 1, 1a, 1b, 1c, and 1d.

[00019] Fig. 1l is a top schematic view illustrating an embodiment of the coupling between the J-slots of the drag blocks and the lugs of the tubular support member of the apparatus of Figs. 1, 1a, 1b, 1c, and 1d.

[00020] Fig. 1m is a top schematic view illustrating an embodiment of the coupling between the J-slots of the drag blocks and the lugs of the tubular support member of the apparatus of Figs. 1, 1a, 1b, 1c, and 1d.

[00021] Fig. 2 is a cross-sectional view illustrating an embodiment of the apparatus of Figs. 1, 1a, 1b, 1c, and 1d during the radial expansion of the tubular member within the borehole within the subterranean formation.

[00022] Fig. 2a is a fragmentary cross-sectional view illustrating an embodiment of a section of the apparatus of Figs. 1, 1a, 1b, 1c, and 1d during the radial expansion of the tubular member within the borehole within the subterranean formation.

[00023] Fig. 2b is a fragmentary cross-sectional view illustrating an embodiment of a section of the apparatus of Figs. 1, 1a, 1b, 1c, and 1d during the radial expansion of the tubular member within the borehole within the subterranean formation.

[00024] Fig. 2c is a fragmentary cross-sectional view illustrating an embodiment of a section of the apparatus of Figs. 1, 1a, 1b, 1c, and 1d during the radial expansion of the tubular member within the borehole within the subterranean formation.

[00025] Fig. 2d is a fragmentary cross-sectional view illustrating an embodiment of a section of the apparatus of Figs. 1, 1a, 1b, 1c, and 1d during the radial expansion of the tubular member within the borehole within the subterranean formation.

[00026] Fig. 2e is a top schematic view illustrating an embodiment of the J-slots of the drag blocks and the lugs of the tubular support member of the apparatus of Figs. 2, 2a, 2b, 2c, and 2d.

[00027] Fig. 2f is a top schematic view illustrating an embodiment of the J-slots of the drag blocks and the lugs of the tubular support member of the apparatus of Figs. 2, 2a, 2b, 2c, and 2d.

[00028] Fig. 2g is a top schematic view illustrating an embodiment of the J-slots of the drag blocks and the lugs of the tubular support member of the apparatus of Figs. 2, 2a, 2b, 2c, and 2d.

[00029] Fig. 2h is a top schematic view illustrating an embodiment of the J-slots of the drag blocks and the lugs of the tubular support member of the apparatus of Figs. 2, 2a, 2b, 2c, and 2d.

[00030] Fig. 3 is a cross-sectional view illustrating an embodiment of the placement of an apparatus for radially expanding a tubular member within a wellbore casing within a subterranean formation.

[00031] Fig. 3a is a fragmentary cross-sectional view illustrating an embodiment of the placement of a section of the apparatus for radially expanding a tubular member within a wellbore casing within a subterranean formation of Fig. 3.

[00032] Fig. 3b is a fragmentary cross-sectional view illustrating an embodiment of the placement of a section of the apparatus for radially expanding a tubular member within a wellbore casing within a subterranean formation of Fig. 3.

[00033] Fig. 3c is a fragmentary cross-sectional view illustrating an embodiment of the placement of a section of the apparatus for radially expanding a tubular member within a wellbore casing within a subterranean formation of Fig. 3.

[00034] Fig. 3d is a cross-sectional view illustrating an embodiment of the expansion cone support body of the apparatus of Figs. 3, 3a, 3b, and 3c.

[00035] Fig. 3e is a cross-sectional view illustrating an embodiment of the expansion cone support body of Fig. 3d.

[00036] Fig. 3f is a side view illustrating an embodiment of an expansion cone segment for use in the apparatus of Figs. 3, 3a, 3b, and 3c.

[00037] Fig. 3g is a front view illustrating an embodiment of the expansion cone segment of Fig. 3f.

[00038] Fig. 3h is a top view illustrating an embodiment of the expansion cone segment of Fig. 3f.

[00039] Fig. 3i is a top view illustrating an embodiment of interlocking expansion cone segments for use in the apparatus of Figs. 3, 3a, 3b, and 3c.

[00040] Fig. 3j is a top fragmentary circumferential view illustrating an embodiment of the coupling arrangement between the expansion cone segments and the split ring collar for use in the apparatus of Figs. 3, 3a, 3b, and 3c.

[00041] Fig. 4 is a cross-sectional view illustrating an embodiment of the placement of the apparatus of Figs. 3, 3a, 3b, and 3c including an expandable tubular member within an expandable tubular member within a subterranean formation.

[00042] Fig. 4a is a fragmentary cross-sectional view illustrating an embodiment of the placement of a section of the apparatus of Figs. 3, 3a, 3b, and 3c during the expansion of an expandable tubular member within an expandable tubular member within a subterranean formation.

[00043] Fig. 4b is a fragmentary cross-sectional view illustrating an embodiment of the placement of a section of the apparatus of Figs. 3, 3a, 3b, and 3c during the expansion of an expandable tubular member within an expandable tubular member within a subterranean formation.

[00044] Fig. 4c is a fragmentary cross-sectional view illustrating an embodiment of the placement of a section of the apparatus of Figs. 3, 3a, 3b, and 3c during the expansion of an expandable tubular member within an expandable tubular member within a subterranean formation.

[00045] Fig. 4d is a fragmentary cross-sectional view illustrating an embodiment of the placement of a section of the apparatus of Figs. 3, 3a, 3b, and 3c during the expansion of an expandable tubular member within an expandable tubular member within a subterranean formation.

[00046] Fig. 5 is a cross-sectional view illustrating an embodiment of the operation of the apparatus of Figs. 4, 4a, 4b, 4c, and 4d during the radial expansion of the expandable tubular member within the borehole within the subterranean formation.

[00047] Fig. 5a is a fragmentary cross-sectional view illustrating an embodiment of the operation of a section of the apparatus of Figs. 4, 4a, 4b, 4c, and 4d during the radial expansion of the expandable tubular member within the borehole within the subterranean formation.

[00048] Fig. 5b is a fragmentary cross-sectional view illustrating an embodiment of the operation of a section of the apparatus of Figs. 4, 4a, 4b, 4c, and 4d during the radial expansion of the expandable tubular member within the borehole within the subterranean formation.

[00049] Fig. 5c is a fragmentary cross-sectional view illustrating an embodiment of the operation of a section of the apparatus of Figs. 4, 4a, 4b, 4c, and 4d during the radial expansion of the expandable tubular member within the borehole within the subterranean formation.

[00050] Fig. 5d is a fragmentary cross-sectional view illustrating an embodiment of the operation of a section of the apparatus of Figs. 4, 4a, 4b, 4c, and 4d during the radial expansion of the expandable tubular member within the borehole within the subterranean formation.

[00051] Fig. 6 is a cross-sectional view illustrating an embodiment of the placement of an apparatus for radially expanding a tubular member within a borehole within a subterranean formation.

[00052] Fig. 6a is a fragmentary cross-sectional view illustrating an embodiment of the placement of a section of the apparatus for radially expanding a tubular member within a borehole within a subterranean formation of Fig. 6.

[00053] Fig. 6b is a fragmentary cross-sectional view illustrating an embodiment of the placement of a section of the apparatus for radially expanding a tubular member within a borehole within a subterranean formation of Fig. 6.

[00054] Fig. 6c is a fragmentary cross-sectional view illustrating an embodiment of the placement of a section of the apparatus for radially expanding a tubular member within a borehole within a subterranean formation of Fig. 6.

[00055] Fig. 6d is a fragmentary cross-sectional view illustrating an embodiment of the placement of a section of the apparatus for radially expanding a tubular member within a borehole within a subterranean formation of Fig. 6.

[00056] Fig. 6e is a cross-sectional view illustrating an embodiment of the expansion cone support body of the apparatus of Figs. 6, 6a, 6b, and 6d.

[00057] Fig. 6f is a cross-sectional view illustrating an embodiment of the expansion cone support body of Fig. 6e.

[00058] Fig. 6g is a side view illustrating an embodiment of an expansion cone segment for use in the apparatus of Figs. 6, 6a, 6b, and 6d.

[00059] Fig. 6h is a front view illustrating an embodiment of the expansion cone segment of Fig. 6g.

[00060] Fig. 6i is a top view illustrating an embodiment of the expansion cone segment of Fig. 6g.

[00061] Fig. 6j is a top view illustrating an embodiment of interlocking expansion cone segments for use in the apparatus of Figs. 6, 6a, 6b, and 6d.

[00062] Fig. 6k is a top fragmentary circumferential view illustrating an embodiment of the coupling arrangement between the expansion cone segments and the split ring collar for use in the apparatus of Figs. 6, 6a, 6b, and 6d.

[00063] Fig. 7 is a cross-sectional view illustrating an embodiment of the placement of the apparatus of Figs. 6, 6a, 6b, and 6d including an expandable tubular member within a borehole within a subterranean formation.

[00064] Fig. 7a is a fragmentary cross-sectional view illustrating an embodiment of the placement of a section of the apparatus of Figs. 6, 6a, 6b, and 6d including an expandable tubular member within a borehole within a subterranean formation.

[00065] Fig. 7b is a fragmentary cross-sectional view illustrating an embodiment of the placement of a section of the apparatus of Figs. 6, 6a, 6b, and 6d including an expandable tubular member within a borehole within a subterranean formation.

[00066] Fig. 7c is a fragmentary cross-sectional view illustrating an embodiment of the placement of a section of the apparatus of Figs. 6, 6a, 6b, and 6d including an expandable tubular member within a borehole within a subterranean formation.

[00067] Fig. 8 is a cross-sectional view illustrating an embodiment of the operation of the apparatus of Figs. 7, 7a, 7b, 7c, and 7d during the radial expansion of the expandable tubular member within a borehole within a subterranean formation.

[00068] Fig. 8a is a fragmentary cross-sectional view illustrating an embodiment of the operation of a section of the apparatus of Figs. 7, 7a, 7b, 7c, and 7d during the radial expansion of the expandable tubular member within a borehole within a subterranean formation.

[00069] Fig. 8b is a fragmentary cross-sectional view illustrating an embodiment of the operation of a section of the apparatus of Figs. 7, 7a, 7b, 7c, and 7d during the radial expansion of the expandable tubular member within a borehole within a subterranean formation.

[00070] Fig. 8c is a fragmentary cross-sectional view illustrating an embodiment of the operation of a section of the apparatus of Figs. 7, 7a, 7b, 7c, and 7d during the radial expansion of the expandable tubular member within a

borehole within a subterranean formation.

[00071] Fig. 8d is a fragmentary cross-sectional view illustrating an embodiment of the operation of a section of the apparatus of Figs. 7, 7a, 7b, 7c, and 7d during the radial expansion of the expandable tubular member within a borehole within a subterranean formation.

[00072] Fig. 9 is a fragmentary cross sectional view illustrating an embodiment of an expansion cone assembly in an unexpanded position.

[00073] Fig. 9a is a cross sectional view illustrating an embodiment of the expansion cone assembly of Fig. 9.

[00074] Fig. 10 is a fragmentary cross sectional view illustrating an embodiment of the expansion cone assembly of Fig. 9 in an expanded position.

[00075] Fig. 10a is a cross sectional view illustrating an embodiment of the expansion cone assembly of Fig. 10.

[00076] Fig. 11 is a fragmentary cross sectional view illustrating an embodiment of an expansion cone assembly in an unexpanded position.

[00077] Fig. 11a is a cross sectional view illustrating an embodiment of the expansion cone assembly of Fig. 11.

[00078] Fig. 12 is a fragmentary cross sectional view illustrating an embodiment of the expansion cone assembly of Fig. 11 in an expanded position.

[00079] Fig. 12a is a cross sectional view illustrating an embodiment of the expansion cone assembly of Fig. 12.

[00080] Fig. 13 is a fragmentary cross sectional view illustrating an embodiment of an expansion cone assembly in an unexpanded position.

[00081] Fig. 13a is a cross sectional view illustrating an embodiment of the expansion cone assembly of Fig. 13.

[00082] Fig. 13b is a fragmentary top circumferential view illustrating an embodiment of the expansion cone segment assembly of Fig. 13 that illustrates the interleaved sets of collets.

[00083] Fig. 13c is a fragmentary cross sectional view illustrating an embodiment of the interleaved collets of Fig. 13b.

[00084] Fig. 14 is a fragmentary cross sectional view illustrating an embodiment of the expansion cone assembly of Fig. 13 in an expanded position.

[00085] Fig. 14a is a cross sectional view illustrating an embodiment of the expansion cone assembly of Fig. 14.

[00086] Fig. 15 is a cross-sectional view illustrating an embodiment of the placement of an apparatus for radially expanding a tubular member within a borehole within a subterranean formation.

[00087] Fig. 15a is a fragmentary cross-sectional view illustrating an embodiment of the placement of a section of the apparatus for radially expanding a tubular member within a borehole within a subterranean formation of Fig. 15.

[00088] Fig. 15b is a fragmentary cross-sectional view illustrating an embodiment of the placement of a section of the apparatus for radially expanding a tubular member within a borehole within a subterranean formation of Fig. 15.

[00089] Fig. 15c is a fragmentary cross-sectional view illustrating an embodiment of the placement of a section of the apparatus for radially expanding a tubular member within a borehole within a subterranean formation of Fig. 15.

[00090] Fig. 15d is a cross-sectional view illustrating an embodiment of the expansion cone support body of the apparatus of Figs. 15, 15a, 15b, and 15c.

[00091] Fig. 15e is a cross-sectional view illustrating an embodiment of the expansion cone support body of Fig. 15d.

[00092] Fig. 15f is a side view illustrating an embodiment of an expansion cone segment for use in the apparatus of Figs. 15, 15a, 15b, and 15c.

[00093] Fig. 15g is a front view illustrating an embodiment of the expansion cone segment of Fig. 15f.

[00094] Fig. 15h is a top view illustrating an embodiment of the expansion cone segment of Fig. 15f.

[00095] Fig. 15i is a top view illustrating an embodiment of interlocking expansion cone segments for use in the apparatus of Figs. 15, 15a, 15b, and 15c.

[00096] Fig. 15j is a top fragmentary circumferential view illustrating an embodiment of the coupling arrangement between the expansion cone segments and the split ring collar for use in the apparatus of Figs. 15, 15a, 15b, and 15c.

[00097] Fig. 16 is a cross-sectional view illustrating an embodiment of the placement of the apparatus of Figs. 15, 15a, 15b, 15c, 15d, 15e, 15f, 15g, 15h, 15i, and 15j including an expandable tubular member within a borehole within a subterranean formation.

[00098] Fig. 16a is a fragmentary cross-sectional view illustrating an embodiment of the placement of a section of the apparatus of Figs. 15, 15a, 15b, 15c, 15d, 15e, 15f, 15g, 15h, 15i, and 15j including an expandable tubular member within a borehole within a subterranean formation.

[00099] Fig. 16b is a fragmentary cross-sectional view illustrating an embodiment of the placement of a section of the apparatus of Figs. 15, 15a, 15b, 15c, 15d, 15e, 15f, 15g, 15h, 15i, and 15j including an expandable tubular member within a borehole within a subterranean formation.

[000100] Fig. 16c is a fragmentary cross-sectional view illustrating an embodiment of the placement of a section of the apparatus of Figs. 15, 15a, 15b, 15c, 15d, 15e, 15f, 15g, 15h, 15i, and 15j including an expandable tubular member within a borehole within a subterranean formation.

[000101] Fig. 17 is a cross-sectional view illustrating an embodiment of the operation of the apparatus of Figs. 16, 16a, 16b, and 16c during the radial expansion of the expandable tubular member within a borehole within a subterranean formation.

[000102] Fig. 17a is a fragmentary cross-sectional view illustrating an embodiment of the operation of a section of the apparatus of Figs. 16, 16a, 16b, and 16c during the radial expansion of the expandable tubular member within a borehole within a subterranean formation.

[000103] Fig. 17b is a fragmentary cross-sectional view illustrating an embodiment of the operation of a section of the apparatus of Figs. 16, 16a, 16b, and 16c during the radial expansion of the expandable tubular member within a borehole within a subterranean formation.

[000104] Fig. 17c is a fragmentary cross-sectional view illustrating an embodiment of the operation of a section of the apparatus of Figs. 16, 16a, 16b, and 16c during the radial expansion of the expandable tubular member within a borehole within a subterranean formation.

[000105] Fig. 18a is a cross sectional view illustrating an embodiment of a segmented expansion cone assembly in an unexpanded position.

[000106] Fig. 18b is a fragmentary circumferential top view illustrating an embodiment of the expansion cone and split ring collar of Fig. 18a.

[000107] Fig. 18c is a fragmentary cross-sectional view illustrating an embodiment of the expansion cone support flange of the expansion cone assembly of Fig. 18a.

[000108] Fig. 18d is a cross-sectional view illustrating an embodiment of the expansion cone support flange of Fig. 18c.

[000109] Fig. 19a is a cross sectional view illustrating an embodiment of the segmented expansion cone assembly of Fig. 18a in an expanded position.

[000110] Fig. 19b is a fragmentary circumferential top view illustrating an embodiment of the expansion cone

of Fig. 19a.

[000111] Fig. 20a is a top circumferential view illustrating an embodiment of an interlocking expansion cone segment geometry.

[000112] Fig. 20b is a top circumferential view illustrating an embodiment of an interlocking expansion cone segment geometry.

[000113] Fig. 20c is a top circumferential view illustrating an embodiment of an interlocking expansion cone segment geometry.

[000114] Fig. 20d is a top circumferential view illustrating an embodiment of an interlocking expansion cone segment geometry.

[000115] Fig. 20e is a top circumferential view illustrating an embodiment of an interlocking expansion cone segment geometry.

[000116] Fig. 20f is a top circumferential view illustrating an embodiment of an interlocking expansion cone segment geometry.

[000117] Fig. 20g is a top circumferential view illustrating an embodiment of an interlocking expansion cone segment geometry.

[000118] Fig. 20h is a top circumferential view illustrating an embodiment of an interlocking expansion cone segment geometry.

[000119] Fig. 20i is a top circumferential view illustrating an embodiment of an interlocking expansion cone segment geometry.

[000120] Fig. 20j is a top circumferential view illustrating an embodiment of an interlocking expansion cone segment geometry.

[000121] Fig. 20k is a top circumferential view illustrating an embodiment of an interlocking expansion cone segment geometry.

[000122] Fig. 20l is a top circumferential view illustrating an embodiment of an interlocking expansion cone segment geometry.

[000123] Fig. 20m is a top circumferential view illustrating an embodiment of an interlocking expansion cone segment geometry.

[000124] Fig. 21a is a fragmentary cross sectional view illustrating an embodiment of a system for radially expanding a tubular member in a first direction.

[000125] Fig. 21b is a fragmentary cross sectional view illustrating an embodiment of a system for radially expanding a tubular member in a second direction.

[000126] Fig. 22a is a side view illustrating an embodiment of the operation of the system of Figs. 21a and 21b.

[000127] Fig. 22b is a side view illustrating an embodiment of the operation of the system of Figs. 21a and 21b.

[000128] Fig. 23a is cross sectional view illustrating an embodiment of the system of Fig. 22a.

[000129] Fig. 23b is cross sectional view illustrating an embodiment of the system of Fig. 22b.

[000130] Fig. 24 is a schematic view illustrating an embodiment of an expansion device used with the system of Figs. 21a and 21b.

[000131] Fig. 25a is a fragmentary cross sectional view illustrating an embodiment of the operation of the system of Figs. 21a and 21b.

[000132] Fig. 25b is a fragmentary cross sectional view illustrating an embodiment of the operation of the system of Figs. 21a and 21b.

[000133] Fig. 25c is a fragmentary cross sectional view illustrating an embodiment of the operation of the system of Figs. 21a and 21b.

[000134] Fig. 26a is a side view illustrating an embodiment of a system for radially expanding a tubular member.

[000135] Fig. 26b is a cross sectional view illustrating an embodiment of the operation of the system for radially expanding a tubular member of Fig. 26a.

[000136] Fig. 27a is a cross sectional view illustrating an embodiment of the system of Figs. 26a.

[000137] Fig. 27b is a cross sectional view illustrating an embodiment of the system of Figs. 26b.

[000138] Fig. 28 is a side view illustrating an embodiment of a system for radially expanding a tubular member.

[000139] Fig. 28a is a side view illustrating an embodiment of the system for radially expanding a tubular member illustrated in Fig. 28.

[000140] Fig. 29a is a cross sectional view illustrating an embodiment of the system illustrated in Fig. 28.

[000141] Fig. 29b is a cross sectional view illustrating an embodiment of the system illustrated in Fig. 28.

[000142] Fig. 29c is a cross sectional view illustrating an embodiment of the system illustrated in Fig. 28 in operation.

[000143] Fig. 29d is a cross sectional view illustrating an embodiment of the system illustrated in Fig. 28 in operation.

[000144] Fig. 29e is a top view illustrating an embodiment of the system illustrated in Fig. 28.

[000145] Fig. 30a is a side view illustrating an embodiment of a system for radially expanding a tubular member.

[000146] Fig. 30b is a side view illustrating an embodiment of the operation of the system of Fig. 30a for radially expanding a tubular member.

[000147] Fig. 30c is a cross sectional view illustrating an embodiment of a system of Fig. 30a for radially expanding a tubular member.

[000148] Fig. 30d is a cross sectional view illustrating an embodiment of the operation of the system of Fig. 30b for radially expanding a tubular member.

[000149] Fig. 31a is a side view illustrating an embodiment of a system for radially expanding a tubular member.

[000150] Fig. 31b is a side view illustrating an embodiment of the operation of the system of Fig. 31a for radially expanding a tubular member.

[000151] Fig. 32 is a fragmentary cross sectional view illustrating an embodiment of a system for radially expanding a tubular member.

[000152] Fig. 33a is a fragmentary cross sectional view illustrating an embodiment of a system for radially expanding a tubular member.

[000153] Fig. 33b is a fragmentary cross sectional view illustrating an embodiment of the operation of the system of Fig. 33a for radially expanding a tubular member.

[000154] Fig. 34a is a side view illustrating an embodiment of a system for radially expanding a tubular member.

[000155] Fig. 34b is a side view illustrating an embodiment of the operation of the system for radially expanding a tubular member of Fig. 34a.

[000156] Fig. 34c is a cross sectional view illustrating an embodiment of a system of Fig. 34a for radially

expanding a tubular member.

[000157] Fig. 34d is a cross sectional view illustrating an embodiment of the operation of the system for radially expanding a tubular member of Fig. 34b.

[000158] Fig. 35a is a side view illustrating an embodiment of a system for radially expanding a tubular member.

[000159] Fig. 35b is a side view illustrating an embodiment of the operation of the system for radially expanding a tubular member of Fig. 35a.

[000160] Fig. 35c is a cross sectional view illustrating an embodiment of a system for radially expanding a tubular member of Fig. 35a.

[000161] Fig. 35d is a cross sectional view illustrating an embodiment of the operation of the system for radially expanding a tubular member of Fig. 35b.

[000162] Fig. 36a is a side view illustrating an embodiment of a system for radially expanding a tubular member.

[000163] Fig. 36b is a side view illustrating an embodiment of the operation of the system for radially expanding a tubular member of Fig. 36a.

[000164] Fig. 37a is a side view illustrating an embodiment of a system for radially expanding a tubular member.

[000165] Fig. 37b is a cross sectional view illustrating an embodiment of the system for radially expanding a tubular member of Fig. 37a.

[000166] Fig. 38a is a side view illustrating an embodiment of the operation of the system for radially expanding a tubular member of Fig. 37a.

[000167] Fig. 38b is a cross sectional view illustrating an embodiment of the operation of the system for radially expanding a tubular member of Fig. 37b.

[000168] Fig. 39a is an exploded view illustrating an exemplary embodiment of a system for radially expanding a tubular member.

[000169] Fig. 39b is a cross-sectional view illustrating an exemplary embodiment of the system for radially expanding a tubular member of Fig. 39a.

[000170] Fig. 39c is n cross-sectional view illustrating an exemplary embodiment of the system for radially expanding a tubular member of Fig. 39a.

[000171] Fig. 40a is a cross-sectional view illustrating an exemplary embodiment of a system for radially expanding a tubular member.

[000172] Fig. 40b is a cross-sectional view illustrating an exemplary embodiment of the operation of the system for radially expanding a tubular member of Fig. 40a.

[000173] Fig. 40c is an cross-sectional view illustrating an exemplary embodiment of couplers on the system for radially expanding a tubular member of Fig. 40a.

[000174] Fig. 41a is a cross-sectional view illustrating an exemplary embodiment of an system for radially expanding a tubular member including a laser cladded coating.

[000175] Fig. 41b is a cross-sectional view illustrating an exemplary embodiment of the system for radially expanding a tubular member including a non-uniform laser cladded coating.

[000176] Fig. 42a is a cross-sectional view illustrating an exemplary embodiment of the system for radially expanding a tubular member of Fig. 41a including a diamond coating.

[000177] Fig. 42b is a cross-sectional view illustrating an exemplary embodiment of the system for radially expanding a tubular member of Fig. 41b including a diamond coating.

**Detailed Description of the Illustrative Embodiments**

[000178] Referring initially to Figs. 1, 1a, 1b, 1c, and 1d, an embodiment of an apparatus and method for radially expanding a tubular member will now be described. As illustrated in Figs. 1 and 1a-1d, a wellbore 100 is positioned in a subterranean formation 105. In an exemplary embodiment, the wellbore 100 may include a pre-existing cased section 110. The wellbore 100 may be positioned in any orientation from vertical to horizontal.

[000179] In order to extend the wellbore 100 into the subterranean formation 105, a drill string is used in a well known manner to drill out material from the subterranean formation 105 to form a new wellbore section 115. In a preferred embodiment, the inside diameter of the new wellbore section 115 is greater than or equal to the inside diameter of the preexisting wellbore casing 110.

[000180] A tubular member 120 defining a passage 120a may then be positioned within the wellbore section 115 with an upper end 120b of the tubular member 120 coupled to the wellbore casing 110 and a lower end 120c of the tubular member 120 extending into the wellbore section 115. The tubular member 120 may be positioned within the wellbore section 115 and coupled to the wellbore casing 110 in a conventional manner. In a preferred embodiment, the tubular member 120 is positioned within the wellbore section 115 and coupled to the wellbore casing 110 using one or more of the methods and apparatus disclosed in one or more of the following (1) U.S. patent application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, (4) U.S. patent application serial no. 09/440,338, attorney docket no. 25791.9.02, filed on 11/15/1999, (5) U.S. patent application serial no. 09/523,460, attorney docket no. 25791.11.02, filed on 3/10/2000, (6) U.S. patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, (7) U.S. patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, (8) U.S. patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, (9) U.S. patent application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, (10) PCT patent application serial no. PCT/US00/18635, attorney docket no. 25791.25.02, filed on 7/9/2000, (11) U.S. provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (12) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (13) U.S. provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (14) U.S. provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (15) U.S. provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (16) U.S. provisional patent application serial no. 60/212,359, attorney docket no. 25791.38, filed on 6/19/2000, (17) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (18) U.S. provisional patent application serial no. 60/221,443, attorney docket no. 25791.45, filed on 7/28/2000, (19) U.S. provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (20) U.S. provisional patent application serial no. 60/233,638, attorney docket no. 25791.47, filed on 9/18/2000, (21) U.S. provisional patent application serial no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, (22) U.S. provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on 2/20/2001; and (23) U.S. provisional patent application serial no. 60/262,434, attorney docket no. 25791.51, filed on 1/17/2001; and (24) U.S. provisional patent application serial no. 60/259,486, attorney docket no. 25791.52, filed on 1/3/2001, the disclosures of which are incorporated herein by reference.

[000181] As illustrated in Figs. 1 and 1a-1d, an apparatus 200 for radially expanding a tubular member may then be positioned in the new section 115 of the wellbore 100 within the tubular member 120. The apparatus 200 includes a tubular support member 205 defining an internal passage 205a that is coupled to an end of a tubular coupling 210 defining an internal passage 210a. The other end of the tubular coupling 210 is coupled to an end of a tubular support member 215 defining an internal passage 215a that includes a first lug 215b, a radial passage 215c, a first flange 215d, a second flange 215e, a second lug 215f, and an expansion cone support body 215g. The other end of the tubular support member 215 is coupled to a tubular end stop 220 that defines a passage 220a.

[000182] As illustrated in Figs. 1e and 1f, the expansion cone support body 215g includes a first end 215ga, a tapered hexagonal portion 215gb that includes a plurality of T-shaped slots 215gba provided on each of the external faceted surfaces of the tapered hexagonal portion 215gb, and a second end 215gc. In an exemplary embodiment, the angle of attack of the tapered hexagonal portion 215gb ranges from about 35 to 50 degrees for reasons to be described.

[000183] As illustrated in Figs. 1, 1a, 1b, 1c, 1d, 1g, 1h, and 1i, a plurality of expansion cone segments 225 are provided with each including a first end 225a that includes a T-shaped retaining member 225aa, a second end 225b that includes a T-shaped retaining member 225ba that is operable to mate with and be received within corresponding T-shaped slots 215gba on the tapered hexagonal portion 215gb of the expansion cone support body 215g, a first external surface 225bb, a second external surface 225bc, and a third external surface 225bd. In an exemplary embodiment, a total of six expansion cone segments 225 are provided that are slidably coupled to corresponding sides of the tapered hexagonal portion 215gb of the expansion cone support body 215g.

[000184] In an exemplary embodiment, the width of the first external surface 225bb of each expansion cone segment 225 increases in the direction of the second external surface 225bc, the width of the second external surface 225bc is substantially constant, and the width of the third external surface 225bd decreases in the direction of the first end 225a of each expansion cone segment 225 for reasons to be described. In an exemplary embodiment, the first external surface 225bb of each expansion cone segment 225 tapers upwardly in the direction of the second external surface 225bc, the second external surface 225bc tapers upwardly in the direction of the third external surface 225bd, and the third external surface 225bd tapers downwardly in the direction of the first end 225a of each expansion cone segment 225 for reasons to be described. In an exemplary embodiment, the angle of attack of the taper of the first external surface 225bb of each expansion cone segment 225 is greater than the angle of attack of the taper of the second external surface 225bc. In an exemplary embodiment, the first external surface 225bb and second external surface 225bc of each expansion cone segment 225 are arcuate such that when the plurality of expansion cone segment 225 are displaced in the direction of the end stop 220, the first external surfaces 225bb and second external surfaces 225bc of the plurality of expansion cone segments 225 provide a substantially continuous outer circumferential surface for reasons to be described.

[000185] As illustrated in Fig. 1j, in an exemplary embodiment, the external surfaces 225bb, 225bc, and 225bd, of the second ends 225b of the plurality of expansion cone segments 225 are adapted to mate with each other in order to interlock adjacent expansion cone segments 225.

[000186] As illustrated in Figs. 1, 1a, 1b, 1c, 1d, and 1k, a split ring collar 230 defines a passage 230a for receiving the tubular support member 215 and includes a first end with a plurality of T-shaped slots 230b for receiving and mating with corresponding T-shaped retaining members 225aa of the plurality of expansion cone segments 225 and a second end that includes an L-shaped retaining member 230c. In an exemplary embodiment,

the split ring collar 230 is a conventional split ring collar commercially available from Halliburton Energy Services modified in accordance with the teachings of the present disclosure.

[000187] As illustrated in Figs. 1, 1a, 1b, 1c, 1d, and 1m, a drag block assembly 235 that defines a passage 235a for receiving the tubular support member 215 is provided that includes a first end that includes an L-shaped slot 235b for receiving and mating with the L-shaped retaining member 230c of the split ring collar 230, one or more conventional drag block elements 235c, and a J-shaped slot 235d including a retaining slot 235da for receiving the second lug 215f of the tubular support member 215. In an exemplary embodiment, the longitudinal axis of the J-shaped slot 235d of the drag block assembly 235 is substantially parallel to the longitudinal axis of the tubular support member 215 for reasons to be described.

[000188] A first conventional packer cup assembly 240 that defines a passage 240a for receiving the tubular support member 215 includes a first end 240b that mates with the second flange 215e of the tubular support member 215, a conventional sealing cup 240c, and a second end 240d. A tubular spacer 245 that defines a passage 245a for receiving the tubular support member 215 includes a first end 245b that mates with the second end 240c of the first packer cup assembly 240 and a second end 245c. A second conventional packer cup assembly 250 that defines a passage 250a for receiving the tubular support member 215 includes a first end 250b that mates with the second end 245c of the spacer 245, a conventional sealing cup 250c, and a second end 250d that mates with the first flange 215d of the tubular support member 215.

[000189] As illustrated in Figs. 1, 1a, 1b, 1c, 1d, and 1l, a drag block assembly 255 that defines a passage 255a for receiving the tubular support member 215 is provided that includes a first end that includes sealing members, 255b and 255c, one or more conventional drag block elements 255d, and a J-shaped slot 255e including a retaining slot 255ea for receiving the first lug 215b of the tubular support member 215. In an exemplary embodiment, the longitudinal axis of the J-shaped slot 255e of the drag block assembly 255 is substantially parallel to the longitudinal axis of the tubular support member 215 for reasons to be described.

[000190] In an exemplary embodiment, during operation of the apparatus 200, as illustrated in Figs. 1 and 1a, 1b, 1c, 1d, 1e, 1f, 1g, 1h ,1i ,1j, 1k, 1l, and 1m, the apparatus may be positioned in the wellbore 115, within the tubular member 120, with the first and second lugs, 215b and 215f, respectively, positioned within the retaining slots, 255ea and 235da, respectively, of the J-slots, 255e and 235da, respectively, of the drag block assembly 255 and 235, respectively. In this manner, the drag block assembly 235 is maintained in a substantially stationary position relative to the tubular support member 215 thereby preventing the expansion cone segments 225 from being displaced downwardly in the longitudinal direction relative to the tubular support member 215 towards the end stop 220. Furthermore, in this manner, the drag block assembly 255 is also maintained in a substantially stationary position relative to the tubular support member 215 thereby preventing the drag block assembly 255 from sealing off the radial passage 215c. In an exemplary embodiment, during the placement of the apparatus 200 within the wellbore 115 and the tubular member 120, the radial passage 215c permits fluidic materials outside of the tubular support member 215 to pass into the passage 215a thereby minimizing overpressure conditions within the annulus outside of the tubular support member 215.

[000191] In an exemplary embodiment, the apparatus 200 is positioned within the expandable tubular member 120 such that the expansion cone body 215g, the end stop 220, and the expansion cone segments 225 extend out of the expandable tubular member 120. In this manner, the plurality of expansion cone segments 225 may be driven up the tapered hexagonal portion 215gb of the expansion cone body 215g without engaging the expandable tubular member 120.

[000192] The tubular support member 215 may then be rotated relative to the drag block assemblies, 235 and 255, thereby displacing the lugs, 215f and 215b, respectively, with respect to the J-shaped slots, 235d and 255e, respectively. The tubular support member 215 may then be displaced in an upward longitudinal direction relative to the drag block assemblies 235 and 255 which is towards the tubular end stop 220 and which results in the drag block assemblies 235 and 255 being displaced in a downward longitudinal direction relative to the tubular support member 215. During the upward longitudinal displacement of the tubular support member 215 relative to the drag block assemblies 235 and 255, the drag block assemblies 235 and 255 are maintained in a substantially stationary position with respect to the expandable tubular member 120 by the frictional forces exerted by the drag blocks 235c and 255d of the drag block assemblies 235 and 255, respectively, on the expandable tubular member 120. During the upward longitudinal displacement of the tubular support member 215 relative to the drag block assemblies 235 and 255, the lugs 215f and 215b are guided in a substantially longitudinal direction by the J-slots 235d and 255e, respectively, of the drag block assemblies 235 and 255.

[000193] The downward longitudinal displacement of the drag block assembly 235 relative to the tubular support member 215 displaces the split ring collar 230 along with the expansion cone segments 225. As a result, the expansion cone segments 225 are driven up the tapered hexagonal portion 215gb of the expansion cone support body 215g until the end faces of the plurality of expansion cone segments 225 impact the stop member 220 which increases the outside diameter of the portion of the apparatus 200 defined by the plurality of expansion cone segments 225. In an exemplary embodiment, once the expansion cone segments 225 impact the stop member 220, the outer surfaces 225bb and 225bc of the plurality of expansion cone segments 225 provide a substantially continuous outer surface in the circumferential direction having a diameter that is greater than the inside diameter of the expandable tubular member 120. The downward longitudinal displacement of the drag block assembly 255 relative to the tubular support member 215 seals off the radial passage 215c thereby preventing the pressurized fluidic material 275 from entering the annulus surrounding the tubular support member 215 through the radial passage 215c.

[000194] In an exemplary embodiment, as illustrated in Figs. 2, 2a, 2b, 2c, 2d, 2e, and 2f, the expandable tubular member 120 may then be radially expanded using the apparatus 200 by injecting a fluidic material 275 through the passages 205a, 210a, and 215a. The injection of the fluidic material 275 pressurizes the interior 120a of the expandable tubular member 120. In addition, the packer cup assemblies 240 and 250 seal off an annular region 120aa adjacent the packer cup assemblies 240 and 250 which is located between the expandable tubular member 120 and the tubular support member 215, resulting in the injection of the fluidic material 275 pressurizing the annular region 120aa.

[000195] The injection of the fluidic material 275 also pressurizes the interior 120a of the expandable tubular member 120 thereby plastically deforming and radially expanding the expandable tubular member 120 off of the expansion cone segments 225. Because the external surfaces 225bb and 225bc of the plurality of expansion cone segments 225 are tapered, the plastic deformation and radial expansion of the expandable tubular member 120 proximate the plurality of expansion cone segments 225 is facilitated. Furthermore, in an exemplary embodiment, the injection of the fluidic material 275 also pressurizes the annular region 120aa defined between the interior surface of the expandable tubular member 120 and the exterior surface of the tubular support member 215 that is bounded on the upper end by the packer cup assembly 240 and on the lower end by the plurality of expansion cone segments 225. Furthermore, in an exemplary embodiment, the pressurization of the annular region 120aa also radially expands the surrounding portion of the expandable tubular member 120. In this manner, the plastic

deformation and radial expansion of the expandable tubular member 120 is enhanced. Furthermore, during operation of the apparatus 200, the packer cup assemblies 240 and 250 prevent the pressurized fluidic material 275 from passing above and beyond the packer cup assemblies 240 and 250 and thereby define the length of the pressurized annular region 120aa. In an exemplary embodiment, the pressurization of the annular region 120aa decreases the operating pressures required for plastic deformation and radial expansion of the expandable tubular member 120 by as much as 50% and also reduces the angle of attack of the tapered external surfaces 225bb and 225bc of the expansion cone segments 225.

[000196] The radial expansion of the expandable tubular member 120 may then continue until the upper end 120b of the expandable tubular member is radially expanded and plastically deformed along with the overlapping portion of the wellbore casing 110. Because the plurality of expansion cone segments 225 may be adjustably positioned from an outside diameter less than the inside diameter of the expandable tubular member 120 to an outside diameter substantially equal to the inside diameter of the pre-existing casing 110, the resulting wellbore casing, including the casing 110 and the radially expanded tubular member 120, created by the operation of the apparatus 200 may have a single substantially constant inside diameter thereby providing a mono-diameter wellbore casing.

[000197] If the expansion cone segments 225 become lodged within the tubular member 120 during the radial expansion process, the tubular support member 215 may be displaced in the downward longitudinal direction and then rotated relative to the drag block assemblies 235 and 255, thereby positioning the lugs 215b and 215f, respectively, within the retaining slots, 255ea and 235da, respectively, of the J-slots, 255e and 235d, respectively. As a result, the expansion cone segments 225 will be displaced down the tapered hexagonal portion 215gb of the expansion cone support body 215g and away from the end stop 220 thereby decreasing the outside diameter of the portion of the apparatus 200 defined by the plurality of expansion cone segments 225. In this manner, the tubular support member 205, the tubular support member 210, the tubular support member 215, the end stop 220, the expansion cone segments 225, the split ring collar 230, the drag block assembly 235, the pack cup assembly 240, the spacer 245, the packer cup assembly 250, and the drag block assembly 255 may then be removed from the tubular member 120.

[000198] During the radial expansion process, the expansion cone segments 225 may be raised out of the expanded portion of the tubular member 120 by applying an axial force to the tubular support member 215. In a preferred embodiment, during the radial expansion process, the expansion cone segments 225 are raised at approximately the same rate as the tubular member 120 is expanded in order to keep the tubular member 120 stationary relative to the new wellbore section 115. In an alternative preferred embodiment, the expansion cone segments 225 are maintained in a stationary position during the radial expansion process thereby allowing the tubular member 120 to be radially expanded and plastically deformed off of the expansion cone segments 225 and into the new wellbore section 115 under the force of gravity and the operating pressure of the interior of the tubular member 120.

[000199] In a preferred embodiment, when the upper end portion of the expandable tubular member 120 and the lower portion of the wellbore casing 110 which overlap with each other are plastically deformed and radially expanded by the expansion cone segments 225, the expansion cone segments 225 are displaced out of the wellbore 100 by both the operating pressure within the interior of the tubular member 120 and a upwardly directed axial force applied to the tubular support member 205.

[000200] In a preferred embodiment, the operating pressure and flow rate of the fluidic material 275 is controllably ramped down when the expansion cone segments 225 reach the upper end portion of the expandable tubular member 120. In this manner, the sudden release of pressure caused by the complete radial expansion and plastic deformation of the expandable tubular member 120 off of the expansion cone segments 225 can be minimized. In a preferred embodiment, the operating pressure is reduced in a substantially linear fashion from 100% to about 10% during the end of the extrusion process beginning when the expansion cone segments 225 are within approximately 5 feet from completion of the extrusion process.

[000201] Alternatively, or in combination, the wall thickness of the upper end portion of the expandable tubular member 120 is tapered in order to gradually reduce the required operating pressure for plastically deforming and radially expanding the upper end portion of the tubular member 120. In this manner, shock loading of the apparatus 200 is reduced.

[000202] Alternatively, or in combination, a shock absorber is provided in the tubular support member 205 in order to absorb the shock caused by the sudden release of pressure. The shock absorber may comprise, for example, any conventional commercially available shock absorber, bumper sub, or jars adapted for use in wellbore operations.

[000203] Alternatively, or in combination, an expansion cone catching structure is provided in the upper end portion of the expandable tubular member 120 in order to catch or at least decelerate the expansion cone segments 225.

[000204] Alternatively, or in combination, during the radial expansion process, an upward axial force is applied to the tubular support member 215 sufficient to plastically deform and radially expand the tubular member 120 off of the external surfaces 225bb and 225bc of the plurality of expansion cone segments 225.

[000205] Alternatively, or in combination, in order to facilitate the pressurization of the interior 120a of the expandable tubular member 120 by the injection of the fluidic materials 275, the region within the wellbore section 115 below the apparatus 200 may be fluidicly sealed off in a convention manner using, for example, a packer.

[000206] Once the radial expansion process is completed, the tubular support member 205, the tubular support member 210, the tubular support member 215, the end stop 220, the expansion cone segments 225, the split ring collar 230, the drag block assembly 235, the pack cup assembly 240, the spacer 245, the packer cup assembly 250, and the drag block assembly 255 are removed from the wellbore 100.

[000207] In an alternative embodiment, as illustrated in Figs. 2h and 2i, the J-slots 235d and 255e include one or more intermediate retaining slots,235db and 255eb, respectively, that permit the relative longitudinal displacement of the tubular support member 215 relative to the drag block assemblies 235 and 255, respectively, to be set at one or more intermediate stop positions. In this manner, the plurality of expansion segments 225 may be positioned at one or more intermediate positions on the tapered hexagonal portion 215gb of the expansion cone support body 215g thereby permitting the outside diameter of the apparatus 200 defined by the expansion cone segments 225 to be adjusted to one or more intermediate sizes. In this manner, the radial expansion and plastic deformation of the expandable tubular member 120 be provided in different operation stages, each having a different expansion diameter. Furthermore, if the plurality of expansion cone segments 225 become lodged within the expandable tubular member 120, then the position of the plurality of expansion cone segments 225 may be adjusted to provide a smaller outside diameter of the apparatus 200 and the radial expansion process may be continued by injecting the fluidic material 275 and/or applying an upward axial force to the tubular support member 215.

[000208] Referring to Figs. 3, 3a, 3b, 3c, 3d, 3e, 3f, 3g, 3h, 3i, and 3j, an alternative embodiment of an apparatus 300 for forming a wellbore casing in a subterranean formation will now be described. The apparatus 300 includes a tubular support member 305 defining an internal passage 305a that is coupled to an end of a tubular coupling 310 defining an internal passage 310a. The other end of the tubular coupling 310 is coupled to an end of a tubular support member 315 defining an internal passage 315a that includes a first flange 315b having oppositely tapered end-walls, 315ba and 315bb, a second flange 315c, a radial passage 315d, a third flange 315e, a fourth flange 315f, a fifth flange 315g having oppositely tapered end-walls 315ga and 315gb, a fifth flange 315h, and an expansion cone support body 315i. The other end of the tubular support member 315 is coupled to a tubular end stop 320 that defines a passage 320a.

[000209] As illustrated in Figs. 3d and 3e, the expansion cone support body 315i includes a first end 315ia, a tapered hexagonal portion 315ib that includes a plurality of T-shaped slots 315iba provided on each of the external faceted surfaces of the tapered hexagonal portion 215ib , and a second end 315ic. In an exemplary embodiment, the angle of attack of the tapered hexagonal portion 315ib ranges from about 35 to 50 degrees for reasons to be described.

[000210] As illustrated in Figs. 3, 3a, 3b, 3c, 3d, 3e, 3f, 3g, and 3h, a plurality of expansion cone segments 325 are provided with each including a first end 325a that includes T-shaped retaining member 325aa, a second end 325b that includes a T-shaped retaining member 325ba that is operable to mate with and be received within corresponding T-shaped slots 315iba on the tapered hexagonal portion 315ib of the expansion cone support body 315i, a first external surface 325bb, a second external surface 325bc, and a third external surface 325bd. In an exemplary embodiment, a total of six expansion cone segments 325 are provided that are slidably coupled to corresponding sides of the tapered hexagonal portion 315ib of the expansion cone support body 315i.

[000211] In an exemplary embodiment, the width of the first external surface 325bb of each expansion cone segments 325 increases in the direction of the second external surface 325bc, the width of the second external surface 325bc is substantially constant, and the width of the third external surface 325bd decreases in the direction of the first ends 325a of each expansion cone segment 225 for reasons to be described. In an exemplary embodiment, the first external surface 325bb of each expansion cone segment 325 tapers upwardly in the direction of the second external surface 325bc, the second external surface 325bc tapers upwardly in the direction of the third external surface 325bd, and the third external surface 325bd tapers downwardly in the direction of the first end 325a of each expansion cone segment 225 for reasons to be described. In an exemplary embodiment, the angle of attack of the taper of the first external surface 325bb of each expansion cone segment 325 is greater than the angle of attack of the taper of the second external surface 325bc. In an exemplary embodiment, the first external surface 325bb and the second external surface 325bc of each expansion cone segment 325 are arcuate such that when the plurality of expansion cone segments 325 are displaced in the direction of the end stop 320, the first external surface 325bb and the second external surface 325bc of the plurality of expansion cone segments 325 provide a substantially continuous outer circumferential surface for reasons to be described.

[000212] As illustrated in Fig. 3i, in an exemplary embodiment, the external surfaces 325bb, 325bc, and 325bd, of the second ends 325b of the plurality of expansion cone segments 325 are adapted to mate with each other in order to interlock adjacent expansion cone segments 325.

[000213] As illustrated in Fig. 3h, 3i, and 3j, a split ring collar 330 that defines a passage 330a for receiving the tubular support member 315 and includes a first end with a plurality of T-shaped slots 330b for receiving and mating with corresponding T-shaped retaining members 325aa of the plurality of expansion cone segments 325 and

a second end that includes an L-shaped retaining member 330c. In an exemplary embodiment, the split ring collar 330 is a conventional split ring collar commercially available from Halliburton Energy Services modified in accordance with the teachings of the present disclosure.

[000214] As illustrated in Fig. 3, 3b and 3c, a collet assembly 335 is provided that includes a support ring 335a that defines a passage 335aa for receiving the tubular support member 315 and is coupled to an end of a resilient collet 335b positioned proximate the fourth flange 315g of the tubular support member 315. Resilient collet 335b includes an upper set of tapered shoulders 335ba and 335bb and a lower set of tapered shoulders 335bc and 335bd which are positioned opposite the upper set of tapered shoulders 335ba and 335bb. The other end of the collet 335b is coupled to an end of a tubular sleeve 335c that defines a passage 335ca. The other end of the tubular sleeve 335c is coupled to an end of a pin 335d. The other end of the pin 335d is coupled to a ring 335e that defines a passage 335ea for receiving the fifth flange 315h of the tubular support member 315. An end of a tubular coupling sleeve 335f that defines a passage 335fa for receiving the tubular support member 315 is received within the opening 335ca of the tubular sleeve 335c that includes a recess 335fb for receiving the fifth flange 315h of the tubular support member 315 and the ring 335e, and a radial passage 335fc for receiving the pin 335d. Another end of the tubular coupling sleeve 335f includes a passage 335fd for receiving the tubular support member 315 and a slot 335fe for receiving the L-shaped retaining member 330c of the split ring collar 330. A ring 335g that defines a passage 335ga for receiving the tubular support member 315, a spring 335h, and a ring 335i that defines a passage 335ia for receiving the tubular support member 315 are also received within the recess 335fb. The ring 335g is positioned proximate one end of the recess 335fb, the ring 335i is positioned proximate the fifth flange 315h of the tubular support member 315 within the other end of the recess 335i and the spring 335h is positioned between the rings 335i and 335i.

[000215] A first conventional packer cup assembly 340 that defines a passage 340a for receiving the tubular support member 315 includes a first end 340b that mates with the fourth flange 315f of the tubular support member 315, a conventional sealing cup 340c, and a second end 340d. A tubular spacer 345 that defines a passage 345a for receiving the tubular support member 315 includes a first end 345b that mates with the second end 340d of the first packer cup assembly 340 and a second end 345c. A second conventional packer cup assembly 350 that defines a passage 350a for receiving the tubular support member 315 includes a first end 350b that mates with the second end 345c of the spacer 345, a conventional sealing cup 350c, and a second end 350d that mates with the third flange 315e of the tubular support member 315.

[000216] As illustrated in Figs. 3, 3a, and 3b, a collet assembly 355 is provided that includes a support ring 355a that defines a passage 355aa for receiving the tubular support member 315 and is coupled to an end of a resilient collet 355b which is positioned proximate the first flange 315b of the tubular support member 315. Resilient collet 355b includes a set of upper tapered shoulders 355ba and 355bb, and a set of lower tapered shoulders 355bc and 355bd, respectively, positioned opposite the set of upper tapered shoulders 355ba and 355bb. The other end of the collet 355b is coupled to an end of a tubular sleeve 355c that defines a passage 355ca. The other end of the tubular sleeve 355c is coupled to an end of a pin 355d. The other end of the pin 355d is coupled to a ring 355e that defines a passage 355ea for receiving the second flange 315c of the tubular support member 315. An end of a tubular sleeve 355f that defines a passage 355fa for receiving the tubular support member 315 is received within the opening 355ca of the tubular sleeve 355c that includes a recess 355fb for receiving the second flange 315c of the tubular support member 315 and the ring 355e, and a radial passage 355fc for receiving the pin 355d. Another end of the tubular sleeve 355f includes a passage 355fd for receiving the tubular support member

315, a recess 355fe for receiving an end of the tubular sleeve 355c, and sealing members 355ff. A ring 355g that defines a passage 355ga for receiving the tubular support member 315 and a spring 355h are also received within the recess 355fb. An end of the ring 355g is positioned proximate the second flange 315c of the tubular support member 315 within an end of the recess 355fb and the other end of the ring 355g is positioned adjacent an end of the spring 355h. The other end of the spring 355h is positioned proximate the other end of the recess 355fb.

[000217] In an exemplary embodiment, during operation of the apparatus 300, as illustrated in Figs. 3, 3a, 3b, 3c, 3d, 3e, 3f, 3g, 3h, 3i, and 3j, the apparatus 300 may be initially positioned in the wellbore 100, within the casing 110, with the collet assemblies 335 and 355 positioned in a neutral position in which the radial passage 315d of the tubular support member 315 is not covered by the tubular sleeve 355f and the expansion cone segments 325 are not driven up the tapered hexagonal portion 315ib of the expansion cone support body 315i of the tubular support member 315 and into contact with the stop member 320. In this manner, fluidic materials within the interior 315a of the tubular support member 315 may pass through the radial passage 315d and into the annulus between the apparatus 300 and the casing 110 thereby preventing over pressurization of the annulus. Furthermore, in this manner, the outside diameter of the plurality of expansion cone segments 325 is less than or equal to the outside diameter of the stop member 320 thereby permitting the apparatus 300 to be displaced within the casing 110.

[000218] As illustrated in Figs. 4, 4a, 4b, 4c, and 4d, the apparatus 300 may then be positioned in the tubular member 120. During the insertion of the apparatus into the tubular member 120, the upper end 120b of the tubular member 120 may impact the tapered shoulders 335bb and 355bb of the collets 335b and 355b, respectively, thereby driving the collets 335b and 355b backward until the tapered shoulders 335bd and 355bd are positioned proximate the tapered shoulders 315ga and 315ba, respectively, of the tubular support member 315. As a result, the support rings 335a and 355a, the collets 335b and 355b, the tubular sleeves 335c and 355c, the pins 335d and 355d, the rings 335e and 355e, and the rings 335g and 355g, of the collet assemblies 335 and 355, respectively, are driven backward, compressing the springs 335h and 355h, and applying axial biasing forces to the tubular coupling sleeve 335f and the tubular sleeve 355f, respectively. In this manner, an axial biasing force is applied to the split ring collar 330 and the plurality of expansion cone segments 325 which prevents the plurality of expansion cone segments 325 from being driven up the tapered hexagonal portion 315ib of the expansion cone support body 315i of the tubular support member 315 and into contact with the stop member 320. Thus, the plurality of expansion cone segments 325 are maintained with an outside diameter which is less than the inside diameter of the tubular member 120, thereby permitting the apparatus 300 to be displaced within the tubular member 120. Furthermore, in this manner, an axial biasing force is applied to the tubular sleeve 355f, which prevents the tubular sleeve 355f from covering the radial passage 315d in the tubular support member 315, allowing fluidic materials within the interior 315a of the tubular support member 315 to pass through the radial passage 315d and into the annulus between the apparatus 300 and the tubular member 120, thereby preventing over pressurization of the annulus.

[000219] The apparatus 300 may then be at least partially positioned in the open hole section 115a of the wellbore section 115, beyond the lower end 120c of the tubular member 120. In an exemplary embodiment, that portion of the apparatus 300 that includes the stop member 320, the expansion cone segments 325, the split ring collar 330, the collet assembly 335, the packer cup assembly 340, the spacer 345, the packer cup assembly 350, and the collet assembly 355 is then positioned in the open hole section 115a of the wellbore section 115, beyond the lower end 120 of the tubular member 120 for reasons to be described. Because the collets 335b and 355b are resilient, once the apparatus 300 has been positioned in the open hole section 115a of the wellbore section 115,

beyond the lower end 120c of the tubular member 120, the tapered shoulders 335ba and 355ba of the collets 335b and 355b, respectively, may spring outwardly in the radial direction.

[000220] The apparatus 300 may then be repositioned at least partially back within the tubular member 120. During the re-insertion of the apparatus 300 into the tubular member 120, the lower end 120c of the tubular member 120 may impact the tapered shoulders 335ba and 355ba of the collets 335b and 355b, respectively, thereby driving the collets forward until the tapered shoulders 335bc and 355bc of the collets 335b and 355b, respectively, are positioned proximate the tapered shoulders 315gb and 315bb, respectively, of the tubular support member 315. As a result, the support rings 335a and 355a, the collets 335b and 355b, the tubular sleeves 335c and 355c, the pins 335d and 355d, the rings 335e and 355e, the tubular coupling sleeve 335f, the tubular sleeve 355f, the rings 335g and 355g, and the ring 335i of the collet assemblies 335 and 355, respectively, are driven forward, thereby compressing the springs 335h and 355h, sealing off the radial passage 315d, and driving the plurality of expansion cone segments 325 up the tapered hexagonal portion 315ib of the expansion cone support body 315i of the tubular support member 315 and into contact with the stop member 320.

[000221] As a result, the outside diameter of the plurality of expansion cone segments 325 expands to become greater than the inside diameter of expandable tubular member 120, thereby permitting the apparatus 300 to be used to radially expand and plastically deform the tubular member 120, and fluidic materials within the interior 315a of the tubular support member 315 may no longer pass through the radial passage 315d into the annulus between the apparatus 300 and the tubular member 120, thereby permitting the interior of the apparatus 300 to be pressurized.

[000222] The apparatus 300 may then be operated to radially expand and plastically deform the tubular member 120 by applying an upward axial force to the tubular support member 315 and/or by injecting a pressurized fluidic material into the tubular support member 315.

[000223] In particular, as illustrated in Figs. 5, 5a, 5b, 5c, and 5d, the expandable tubular member 120 may then be radially expanded using the apparatus 300 by injecting a fluidic material 275 into the apparatus through the passages 305a, 310a, 315a, and 320a. The injection of the fluidic material 275 may pressurize the interior 120a of the expandable tubular member 120. In addition, because the packer cup assemblies 340 and 350 seal off an annular region 120aa below the packer cup assemblies 340 and 350 located between the expandable tubular member 120 and the tubular support member 315, the injection of the fluidic material 275 may also pressurize the annular region 120aa.

[000224] The continued injection of the fluidic material 275 may then pressurize the interior 120a of the expandable tubular member 120, thereby plastically deforming and radially expanding the expandable tubular member 120 off of the plurality of expansion cone segments 325. Because the outer surfaces 325bb and 325bc of each of the plurality of expansion cone segments 325 are tapered, the plastic deformation and radial expansion of the expandable tubular member 120 proximate the plurality of expansion cone segments 325 is facilitated. Furthermore, in an exemplary embodiment, the continued injection of the fluidic material 275 also pressurizes the annular region 120aa defined between the interior surface of the expandable tubular member 120 and the exterior surface of the tubular support member 315 that is bounded on the upper end by the packer cup assembly 340 and on the lower end by the expansion cone segments 325. Furthermore, in an exemplary embodiment, the pressurization of the annular region 120aa also radially expands at least a portion of the surrounding portion of the expandable tubular member 120. In this manner, the plastic deformation and radial expansion of the expandable tubular member 120 is enhanced. Furthermore, during operation of the apparatus 300, the packer cup assemblies 340 and 350 prevent the pressurized fluidic material 275 from passing above and beyond the packer cup assemblies 340 and

350 and thereby define the length of the pressurized annular region 120aa. In an exemplary embodiment, the pressurization of the annular region 120aa decreases the operating pressures required for plastic deformation and radial expansion of the expandable tubular member 120 by as much as 50% and also reduces the angle of attack of the tapered external surfaces 325bb and 325bc on each of the plurality of expansion cone segments 325.

[000225] The radial expansion of the expandable tubular member 120 may then continue until the upper end 120b of the expandable tubular member 120 is radially expanded and plastically deformed along with the overlapping portion of the wellbore casing 110. Because the expansion cone segments 325 may be adjustably positioned from an outside diameter less than the inside diameter of the expandable tubular member 120 to an outside diameter substantially equal to the inside diameter of the pre-existing casing 110, the resulting wellbore casing, including the casing 110 and the radially expanded tubular member 120, created by the operation of the apparatus 300, may have a single substantially constant inside diameter thereby providing a mono-diameter wellbore casing.

[000226] During the radial expansion process, the plurality of expansion cone segments 325 may be raised out of the expanded portion of the tubular member 120 by applying an upward axial force to the tubular support member 315. In a preferred embodiment, during the radial expansion process, the plurality of expansion cone segments 325 are raised at approximately the same rate as the tubular member 120 is expanded in order to keep the tubular member 120 stationary relative to the new wellbore section 115.

[000227] In a preferred embodiment, when the upper end portion of the expandable tubular member 120 and the lower portion of the wellbore casing 110 that overlap with one another are plastically deformed and radially expanded by the plurality of expansion cone segments 325, the plurality of expansion cone segments 325 are displaced out of the wellbore 100 by both the operating pressure within the interior of the tubular member 120 and a upwardly directed axial force applied to the tubular support member 305.

[000228] In a preferred embodiment, the operating pressure and flow rate of the fluidic material 275 is controllably ramped down when the plurality of expansion cone segments 325 reach the upper end portion of the expandable tubular member 120. In this manner, the sudden release of pressure caused by the complete radial expansion and plastic deformation of the expandable tubular member 120 off of the plurality of expansion cone segments 325 can be minimized. In a preferred embodiment, the operating pressure is reduced in a substantially linear fashion from 100% to about 10% during the end of the extrusion process beginning when the plurality of expansion cone segments 325 are within about 5 feet from completion of the extrusion process.

[000229] Alternatively, or in combination, the wall thickness of the upper end portion of the expandable tubular member 120 is tapered in order to gradually reduce the required operating pressure for plastically deforming and radially expanding the upper end portion of the tubular member 120. In this manner, shock loading of the apparatus 300 is reduced.

[000230] Alternatively, or in combination, a shock absorber is provided in the tubular support member 305 in order to absorb the shock caused by the sudden release of pressure. The shock absorber may comprise, for example, any conventional commercially available shock absorber, bumper sub, or jars adapted for use in wellbore operations.

[000231] Alternatively, or in combination, an expansion cone catching structure is provided in the upper end portion of the expandable tubular member 120 in order to catch or decelerate the expansion cone segments 325.

[000232] Alternatively, or in combination, during the radial expansion process, an upward axial force is applied to the tubular support member 315 sufficient to plastically deform and radially expand the tubular member 120 off of the external surfaces, 225bb and 225bc, of the expansion cone segments 325.

[000233] Alternatively, or in combination, in order to facilitate the pressurization of the interior 120a of the expandable tubular member by the injection of the fluidic materials 275, the region within the wellbore section 115 below the apparatus 300 may be fluidicly sealed off in a convention manner using, for example, a packer.

[000234] Once the radial expansion process is completed, the tubular support member 305, the tubular support member 310, the tubular support member 315, the end stop 320, the expansion cone segments 325, the split ring collar 330, the collet assembly 335, the packer cup assembly 340, the spacer 345, the packer cup assembly 350, and the collet assembly 355 are removed from the wellbores 100 and 115.

[000235] Referring to Figs. 6, 6a, 6b, 6c, 6d, 6e, 6f, 6g, 6h, 6i, 6j, and 6k, an alternative embodiment of an apparatus 400 for forming a wellbore casing in a subterranean formation will now be described. The apparatus 400 includes a tubular support member 405 defining an internal passage 405a that is coupled to an end of a tubular coupling 410 defining an internal passage 410a. The other end of the tubular coupling 410 is coupled to an end of a tubular support member 415 defining an internal passage 415a that includes a first flange 415b, a first radial passage 415c, a second radial passage 415d, a second flange 415e, a stepped flange 415f, a third flange 415g, a fourth flange 415h, a fifth flange 415i, and an expansion cone body 415j. The other end of the tubular support member 415 is coupled to a tubular end stop 420 that defines a passage 420a.

[000236] As illustrated in Figs. 6e and 6f, the expansion cone support body 415j includes a first end 415ja, a tapered hexagonal portion 415jb that includes a plurality of T-shaped slots 415jba provided on each of the external faceted surfaces of the tapered hexagonal portion 415jb, and a second end 415jc. In an exemplary embodiment, the angle of attack of the tapered hexagonal portion 415jb ranges from about 35 to 50 degrees for reasons to be described.

[000237] As illustrated in Figs. 6, 6a, 6b, 6c, 6d, 6g, 6h, and 6i, a plurality of expansion cone segments 425 are provided with each including a first end 425a that includes T-shaped retaining member 425aa, second end 425b that includes a T-shaped retaining member 425ba that is operable to mate with and be received within corresponding T-shaped slots 415jba on the tapered hexagonal portion 415jb of the expansion cone support body 415j, a first external surface 425bb, a second external surface 425bc, and a third external surface 425bd. In an exemplary embodiment, a total of six expansion cone segments 425 are provided that are slidably coupled to corresponding sides of the tapered hexagonal portion 415jb of the expansion cone support body 415j.

[000238] In an exemplary embodiment, the width of the first external surface 425bb of each expansion cone segment 425 increases in the direction of the second external surface 425bc, the width of the second external surface 425bc is substantially constant, and the width of the third external surface 425bd decreases in the direction of the first end 425a of each expansion cone segment 225 for reasons to be described. In an exemplary embodiment, the first external surface 425bb of each expansion cone segment 425 tapers upwardly in the direction of the second external surface 425bc, the second external surface 425bc tapers upwardly in the direction of the third external surface 425bd, and the third external surface 425bd tapers downwardly in the direction of the first end 425a of each expansion cone segment 425 for reasons to be described. In an exemplary embodiment, the angle of attack of the taper of the first external surface 425bb of each expansion cone segment 425 is greater than the angle of attack of the taper of the second external surface 425bc. In an exemplary embodiment, the first external surface 425bb and second external surface 425bc of each expansion cone segment 425 are arcuate such that when the

plurality of expansion cone segments 425 are displaced in the direction of the end stop 420, the first external surface 425bb and second external surface 425bc of the plurality of expansion cone segments 425 provide a substantially continuous outer circumferential surface for reasons to be described.

[000239] As illustrated in Fig. 6j, in an exemplary embodiment, the external surfaces 425bb, 425bc, and 425bd, of the second ends 425b of the plurality of expansion cone segments 425 are adapted to mate with each another in order to interlock adjacent expansion cone segments 425.

[000240] As illustrated in Figs. 6, 6a, 6b, 6c, 6d, and 6k, a split ring collar 430 that defines a passage 430a for receiving the tubular support member 415 and includes a first end with a plurality of T-shaped slots 430b for receiving and mating with corresponding T-shaped retaining members 425aa of the plurality of expansion cone segments 425 and a second end that includes an L-shaped retaining member 430c. In an exemplary embodiment, the split ring collar 430 is a conventional split ring collar commercially available from Halliburton Energy Services modified in accordance with the teachings of the present disclosure.

[000241] A dog assembly 435 is provided that includes a tubular sleeve 435a that defines a passage 435aa for receiving the tubular support member 415 and includes a first end having a slot 435ab for receiving and mating with the L-shaped retaining member 430c of the split ring collar 430, a radial passage 435ac, and a recess 435ad for receiving the fifth flange 415a of the tubular support member 415. A second end of the tubular sleeve 435a includes a flange 435ae that mates with the fourth flange 415h of the tubular support member 415. A retaining ring 435b that defines a passage 435ba for receiving the fifth flange 415i is received within the recess 435ad of the tubular sleeve 435a and is coupled to an end of a load transfer pin 435c. The opposite end of the load transfer pin 435c is received within the radial passage 435ac of the tubular sleeve 435a and is coupled to an end of a tubular sleeve 435d that includes a recess 435da at a first end for receiving the tubular sleeve 435a and a radial opening 435dc for receiving a conventional resilient dog 435e. A spring 435f and a ring 435g that defines a passage 435ga for receiving the tubular support member 415 are received within the recess 435ad of the tubular sleeve 435a between a first end of the recess 435ad and the fifth flange 415i of the tubular support member 415.

[000242] A first conventional packer cup assembly 440 that defines a passage 440a for receiving the tubular support member 415 includes a first end 440b that mates with the fourth flange 415g of the tubular support member 415, a conventional sealing cup 440c, and a second end 440d. A tubular spacer 445 that defines a passage 445a for receiving the tubular support member 415 includes a first end 445b that mates with the second end 440d of the first packer cup assembly 440 and a second end 445c. A second conventional packer cup assembly 450 that defines a passage 450a for receiving the tubular support member 415 includes a first end 450b that mates with the second end 445c of the spacer 445, a conventional sealing cup 450c, and a second end 450d that mates with the stepped flange 415f of the tubular support member 415.

[000243] A dog assembly 455 is provided that includes a tubular sleeve 455a that defines a passage 455aa for receiving the tubular support member 415. A first end of the tubular sleeve 455a includes a radial opening 455ab for receiving a conventional resilient dog 455b. A second end of the tubular sleeve 455a includes a recess 455ac and is coupled to an end of a load transfer pin 455c. The opposite end of the load transfer pin 455c is coupled to a retaining ring 455d that defines a passage 455da for receiving the tubular support member 415. A tubular sleeve 455e is received within the recess 455ac of the tubular sleeve 455a that defines a passage 455ea for receiving the tubular support member 415 and includes a first end that includes a radial passage 455eb for receiving the load transfer pin 455c and a recess 455ec for receiving a spring 455f. A ring 455g that defines a passage 455ga for receiving the tubular support member 415 is further received within the recess 455ec of the tubular sleeve 455e

between the spring 455f and the second flange 415e of the tubular support member 415. A second end of the tubular sleeve 455e includes a radial passage 455ed, sealing members 455ef and 455eg, and a recess 455eh that mates with the first flange 415b of the tubular support member 415.

[000244] In an exemplary embodiment, during operation of the apparatus 400, as illustrated in Figs. 6, 6a, 6b, 6c, 6d, 6e, 6f, 6g, 6h, 6i, and 6k, the apparatus 400 may be initially positioned in the wellbore 100, within the casing 110, with the dog assemblies 435 and 455 positioned in a neutral position in which the radial passage 415d of the tubular support member 415 is fluidicly coupled to the radial passage 455ed of the dog assembly 455 and the plurality of expansion cone segments 425 are not driven up the tapered hexagonal portion 415jb of the expansion cone support body 415j of the tubular support member 415 and into contact with the stop member 320. In this manner, fluidic materials within the interior 415a of the tubular support member 415 may pass through the radial passages, 415d and 455ed, into the annulus between the apparatus 400 and the casing 110, thereby preventing over pressurization of the annulus. Furthermore, in this manner, the outside diameter of the plurality of expansion cone segments 425 is less than or equal to the outside diameter of the stop member 420 thereby permitting the apparatus 400 to be displaced within the casing 110.

[000245] As illustrated in Figs. 7, 7a, 7b, and 7c, the apparatus 400 may then be positioned in the tubular member 120. During the insertion of the apparatus 400 into the tubular member 120, the upper end 120b of the tubular member 120 may impact the ends of the resilient dogs 435e and 455b of the dog assemblies 435 and 455, respectively, thereby driving the resilient dogs 435e and 455b backwards off of and adjacent to one side of the flanges 415h and 415f, respectively. As a result of the backward axial displacement of the resilient dog 435e, the tubular sleeve 435d, the pin 435c, the retaining ring 435b, and the ring 435g of the dog assembly 435 are driven backward thereby compressing the spring 435f and applying an axial biasing force to the tubular sleeve 435a that prevents the plurality of expansion cone segments 425 from being displaced toward the end stop 420. As a result of the backward axial displacement of the resilient dog 455b, the tubular sleeve 455a, the pin 455c, the retaining ring 455d, and the ring 455g of the dog assembly 455 are driven backward thereby compressing the spring 455f and applying an axial biasing force to the tubular sleeve 455e that prevents the radial passages 415d and 455ed from being fluidicly decoupled.

[000246] The apparatus 400 may then be positioned at least partially in the open hole section 115a of the wellbore section 115 and beyond the lower end 120c of the tubular member 120. In an exemplary embodiment, the portion of the apparatus 400 that includes the stop member 420, the plurality of expansion cone segments 425, the split ring collar 430, the dog assembly 435, the packer cup assembly 440, the spacer 445, the packer cup assembly 450, and the dog assembly 455 is then positioned in the open hole section 115a of the wellbore section 115, and beyond the lower end 120 of the tubular member 120 for reasons to be described. Because the dogs 435e and 455b of the dog assemblies 435 and 455, respectively, are resilient, once the apparatus 400 has been positioned in the open hole section 115a of the wellbore section 115, beyond the lower end 120c of the tubular member 120, the resilient dogs 435e and 455b of dog assemblies 435 and 455, respectively, may spring outwardly in the radial direction.

[000247] The apparatus 400 may then be repositioned at least partially back within the tubular member 120. During the re-insertion of the apparatus 400 into the tubular member 120, the lower end 120c of the tubular member 120 may impact the ends of the resilient dogs 435e and 455b of the dog assemblies 435 and 455, respectively, thereby driving the resilient dogs 435e and 455b forward until the resilient dogs 435e and 455b are positioned

beyond and adjacent to the other side of the flanges 415h and 415f, respectively, of the tubular support member 415.

[000248] As a result of the forward axial displacement of the resilient dog 435e, the tubular sleeve 435a, the retaining ring 435b, the pin 435c, the tubular sleeve 435d, the spring 435f, and the ring 435g of the dog assembly 435 are displaced in the forward axial direction thereby also displacing the split ring collar 430 and the plurality of expansion cone segments 425 in the forward axial direction. As a result, the plurality of expansion cone segments 425 are driven up the tapered hexagonal portion 415jb of the expansion cone support body 415j of the tubular support member 415 and into contact with the stop member 320.

[000249] As a result of the forward axial displacement of the resilient dog 455b, the tubular sleeve 455a, the pin 455c, the retaining ring 455d, the tubular sleeve 455e, the spring 455f, and the ring 455g of the dog assembly 455 are driven forward in the axial direction thereby fluidicly decoupling the radial passages 415d and 455ed and fluidicly coupling the radial passages 415c and 415d. As a result, fluidic materials within the tubular support member 415 may not pass into the annulus between the tubular support member 415 and the tubular member 120.

[000250] As a result of the forward axial displacement of the resilient dog 435e, the outside diameter of the plurality of expansion cone segments 425 is made greater than the inside diameter of expandable tubular member 120, thereby permitting the apparatus 400 to be used to radially expand and plastically deform the tubular member 120, and fluidic materials within the interior 415a of the tubular support member 415 may no longer pass through the radial passages 415d and 455ed and into the annulus between the apparatus 400 and the tubular member 120, thereby permitting the interior of the apparatus 400 to be pressurized.

[000251] The apparatus 400 may then be operated to radially expand and plastically deform the tubular member 120 by applying an upward axial force to the tubular support member 415 and/or by injecting a pressurized fluidic material into the tubular support member 120.

[000252] In particular, as illustrated in Figs. 8, 8a, 8b, 8c, and 8d, the expandable tubular member 120 may then be radially expanded using the apparatus 400 by injecting a fluidic material 275 into the apparatus 400 through the passages 405a, 310a, 415a, and 420a. The injection of the fluidic material 275 may pressurize the interior 120a of the expandable tubular member 120. In addition, because the packer cup assemblies 440 and 450 seal off an annular region 120aa below the packer cup assemblies 440 and 450 and between the expandable tubular member 120 and the tubular support member 415, the injection of the fluidic material 275 may also pressurize the annular region 120aa.

[000253] The continued injection of the fluidic material 275 may then pressurize the interior 120a of the expandable tubular member 120 thereby plastically deforming and radially expanding the expandable tubular member 120 off of the plurality of expansion cone segments 425. Because the outer surfaces 425bb and 425bc of the plurality of expansion cone segments 425 are tapered, the plastic deformation and radial expansion of the expandable tubular member 120 proximate the plurality of expansion cone segments 425 is facilitated. Furthermore, in an exemplary embodiment, the continued injection of the fluidic material 275 also pressurizes the annular region 120aa defined between the interior surface of the expandable tubular member 120 and the exterior surface of the tubular support member 415 which is bounded on the upper end by the packer cup assembly 440 and on the lower end by the plurality of expansion cone segments 425. Furthermore, in an exemplary embodiment, the pressurization of the annular region 120aa also radially expands at least a portion of the surrounding portion of the expandable tubular member 120. In this manner, the plastic deformation and radial expansion of the expandable tubular member 120 is enhanced. Furthermore, during operation of the apparatus 400, the packer cup assemblies

440 and 450 prevent the pressurized fluidic material 275 from passing above and beyond the packer cup assemblies 440 and 450 and thereby define the length of the pressurized annular region 120aa. In an exemplary embodiment, the pressurization of the annular region 120aa decreases the operating pressures required for plastic deformation and radial expansion of the expandable tubular member 120 by as much as 50% and also reduces the angle of attack of the tapered external surfaces 425bb and 425bc of the plurality of expansion cone segments 425.

[000254] The radial expansion of the expandable tubular member 120 may then continue until the upper end 120b of the expandable tubular member 120 is radially expanded and plastically deformed along with the overlapping portion of the wellbore casing 110. Because the plurality of expansion cone segments 425 may be adjustably positioned from an outside diameter which is less than the inside diameter of the expandable tubular member 120 to an outside diameter which is substantially equal to the inside diameter of the pre-existing casing 110, the resulting wellbore casing, including the casing 110 and the radially expanded tubular member 120 which is created by the operation of the apparatus 400, may have a single substantially constant inside diameter thereby providing a mono-diameter wellbore casing.

[000255] During the radial expansion process, the plurality of expansion cone segments 425 may be raised out of the expanded portion of the tubular member 120 by applying an upward axial force to the tubular support member 415. In a preferred embodiment, during the radial expansion process, the expansion cone segments 425 are raised at approximately the same rate as the tubular member 120 is expanded in order to keep the tubular member 120 stationary relative to the new wellbore section 115.

[000256] In a preferred embodiment, when the upper end portion of the expandable tubular member 120 and the lower portion of the wellbore casing 110 that overlap with one another are plastically deformed and radially expanded by the plurality of expansion cone segments 425, the plurality of expansion cone segments 425 are displaced out of the wellbore 100 by both the operating pressure within the interior of the tubular member 120 and a upwardly directed axial force applied to the tubular support member 405.

[000257] In a preferred embodiment, the operating pressure and flow rate of the fluidic material 275 is controllably ramped down when the plurality of expansion cone segments 425 reach the upper end portion of the expandable tubular member 120. In this manner, the sudden release of pressure caused by the complete radial expansion and plastic deformation of the expandable tubular member 120 off of the plurality of expansion cone segments 425 can be minimized. In a preferred embodiment, the operating pressure is reduced in a substantially linear fashion from 100% to about 10% during the end of the extrusion process beginning when the plurality of expansion cone segments 425 are within about 5 feet from completion of the extrusion process.

[000258] Alternatively, or in combination, the wall thickness of the upper end portion of the expandable tubular member 120 is tapered in order to gradually reduce the required operating pressure for plastically deforming and radially expanding the upper end portion of the tubular member 120. In this manner, shock loading of the apparatus is reduced.

[000259] Alternatively, or in combination, a shock absorber is provided in the tubular support member 405 in order to absorb the shock caused by the sudden release of pressure. The shock absorber may comprise, for example, any conventional commercially available shock absorber, bumper sub, or jars adapted for use in wellbore operations.

[000260] Alternatively, or in combination, an expansion cone catching structure is provided in the upper end portion of the expandable tubular member 120 in order to catch or decelerate the expansion cone segments 425.

[000261] Alternatively, or in combination, during the radial expansion process, an upward axial force is applied to the tubular support member 415 sufficient to plastically deform and radially expand the tubular member 120 off of the external surfaces 225bb and 225bc of the plurality of expansion cone segments 425.

[000262] Alternatively, or in combination, in order to facilitate the pressurization of the interior 120a of the expandable tubular member 120 by the injection of the fluidic materials 275, the region within the wellbore section 115 below the apparatus 400 may be fluidicly sealed off in a convention manner using, for example, a packer.

[000263] Once the radial expansion process is completed, the tubular support member 405, the tubular support member 410, the tubular support member 415, the end stop 420, the expansion cone segments 425, the split ring collar 430, the dog assembly 435, the packer cup assembly 440, the spacer 445, the packer cup assembly 450, and the dog assembly 455 are removed from the wellbores 100 and 115.

[000264] Referring now to Figs. 9, 9a, 10 and 10a, an embodiment of an expansion cone assembly 500 will be described. The assembly 500 includes a tubular support member 505 that defines a passage 505a and includes a flange 505b, an expansion cone support flange assembly 505c, and an end stop 505d. The expansion cone support flange assembly 505c includes a tubular body 505ca and a plurality of equally spaced apart expansion cone segment support members 505cb that extend outwardly from the tubular body in the radial direction such that each includes identical bases 505cba and extensions 505cbb. The support members 505cb further include first sections 505cbc having arcuate conical outer surfaces and second sections 505cbd having arcuate cylindrical outer surfaces for reasons to be described.

[000265] An expansion cone segment assembly 510 is provided that includes a tubular support 510a defining a passage 510aa for receiving the tubular support member 505 and a slot 510ab. A plurality of spaced apart and substantially identical resilient expansion cone segment collets 510b extend from the tubular support 510a in the axial direction that include expansion cone segments 510ba extending therefrom in the axial direction. Each of the expansion cone segments 510ba further include arcuate conical expansion surfaces 510baa for radially expanding an expandable tubular member.

[000266] A split ring collar 515 is provided that defines a passage 515a for receiving the tubular support member 505 that includes an L-shaped retaining member 515b at one end for mating with the slot 510ab of the tubular support 510a of the expansion cone segment assembly 510. Another end of the split ring collar 515 includes an L-shaped retaining member 515c. A tubular sleeve 520 is provided that defines a passage 520a for receiving the tubular support member 505 and which includes a slot 520b for receiving the L-shaped retaining member 515c of the split ring collar 515.

[000267] During operation, the assembly 500 begins in an unexpanded position, as illustrated in Figs. 9 and 9a, with the plurality of expansion cone segments 510ba of the expansion cone segment assembly 510 positioned adjacent to the base of the conical section 505cbc of the expansion cone segment support members 505cb, and with the outside diameter of the plurality of expansion cone segments 510ba less than or equal to the maximum outside diameter of the assembly 500. The assembly 500 may then be expanded, as illustrated in Figs. 10 and 10a, by displacing the tubular sleeve 520, the split ring collar 515, and the expansion cone segment assembly 510 in the axial direction towards the expansion cone segment support members 505cb. As a result, the plurality of expansion cone segments 510ba are driven up the conical section 505cbc of the expansion cone segment support members 505cb and then onto the cylindrical section 505cbd of the expansion cone segment support members 505cb until the plurality of expansion cone segments 510ba engage the end stop 505d. In this manner, the outside diameter of the plurality of expansion segments 510ba is made greater than the maximum diameter of the remaining components of

the assembly 500. Furthermore, the conical outer surfaces 510baa of the plurality of expansion cone segments 510ba may now be used to radially expand a tubular member. In an exemplary embodiment, the extensions 505cbb of the expansion cone segment support members 505cb provide support in the circumferential direction to adjacent expansion cone segments 510ba. In an exemplary embodiment, the outer conical surfaces 510baa of the plurality of expansion cone segments 510ba in the expanded position of the assembly 500 provide a substantially continuous outer conical surfaces in the circumferential direction.

[000268] The assembly 500 may then be returned to the unexpanded position by displacing the tubular sleeve 520, the split ring collar 515, and the expansion cone segment assembly 510 in the axial direction away from the expansion cone segment support members 505cb. As a result, the plurality of expansion cone segments 510ba are displaced off of the cylindrical section 505cbd and the conical section 505cbc of the expansion cone segment support members 505cb. Because the collets 510b of the expansion cone segment assembly 510 are resilient, the expansion segments 510ba are thereby returned to a position in which the outside diameter of the plurality of expansion cone segments 510ba is less than or equal to the maximum diameter of the remaining components of the assembly 500.

[000269] In several alternative embodiments, the assembly 500 is incorporated into the assemblies 200, 300 and/or 400, described above with reference to Figs. 1, 1a, 1b, 1c, 1d, 1e, 1f, 1g, 1h 1,i 1j, 1k, 1l, 1m, 2, 2a, 2b, 2c, 2d, 2e, 2f, 2g, 2h, 3, 3a, 3b, 3c, 3d, 3e, 3f, 3g, 3h, 3i, 3j, 4, 4a, 4b, 4c, 4d, 5, 5a, 5b, 5c, 5d, 6, 6a, 6b, 6c, 6d, 6e, 6f, 6g, 6h, 6i, 6j, 6k, 7, 7a, 7b, 7c, 8, 8a, 8b, 8c, and 8d.

[000270] Referring now to Figs. 11, 11a, 12 and 12a, an embodiment of an expansion cone assembly 600 will be described. The assembly 600 includes a tubular support member 605 that defines a passage 605a and includes an expansion cone support flange assembly 605b and an end stop 605c. The expansion cone support flange assembly 605b includes a tubular body 605ba and a plurality of substantially identical equally spaced apart expansion cone segment support members 605bb that extend outwardly from the tubular body 605ba in the radial direction. The support members 605bb further include first sections 605bba having arcuate cylindrical outer surfaces, second sections 605bbb having arcuate conical outer surfaces, and third sections 605bbc having arcuate cylindrical outer surfaces for reasons to be described.

[000271] An expansion cone segment assembly 610 is provided that includes a tubular support 610a defining a passage 610aa for receiving the tubular support member 605 and a slot 610ab. A plurality of spaced apart and substantially identical resilient expansion cone segment collets 610b extend from the tubular support 610a in the axial direction and include expansion cone segments 610ba extending therefrom in the axial direction. Each of the expansion cone segments 610ba further include arcuate conical expansion surfaces 610baa for radially expanding an expandable tubular member.

[000272] A split ring collar 615 is provided that defines a passage 615a for receiving the tubular support member 605 and which includes an L-shaped retaining member 615b at one end for mating with the slot 610ab of the tubular support 610a of the expansion cone segment assembly 610. Another end of the split ring collar 615 includes an L-shaped retaining member 615c. A tubular sleeve 620 is provided that defines a passage 620a for receiving the tubular support member 605 and which includes a slot 620b for receiving the L-shaped retaining member 615c of the split ring collar 615.

[000273] During operation, the assembly 600 begins in an unexpanded position, as illustrated in Figs. 11 and 11a, with the plurality of expansion cone segments 610ba of the expansion cone segment assembly 610 positioned adjacent to the base of the conical section 605bbb and on the cylindrical section 605bba of the expansion cone

segment support members 605bb, which results in the outside diameter of the plurality of expansion cone segments 610ba being less than or equal to the maximum outside diameter of the assembly 600. The assembly 600 may then be expanded, as illustrated in Figs. 12 and 12a, by displacing the tubular sleeve 620, the split ring collar 615, and the expansion cone segment assembly 610 in the axial direction towards the expansion cone segment support members 605bb. As a result, the plurality of expansion cone segments 610ba are driven up the conical section 605bbb of the expansion cone segment support members 605bb and onto the cylindrical section 605bbc of the expansion cone segment support members 605bb until the plurality of expansion cone segments 610ba engage the end stop 605c. In this manner, the outside diameter of the expansion segments 610ba is made greater than the maximum diameter of the remaining components of the assembly 600. Furthermore, the conical outer surfaces 610baa of the plurality of expansion cone segments 610ba may now be used to radially expand a tubular member. In an exemplary embodiment, the outer conical surfaces 610baa of the plurality of expansion cone segments 610ba in the expanded position of the assembly 600 provide a substantially continuous outer conical surfaces in the circumferential direction.

[000274] The assembly 600 may then be returned to the unexpanded position by displacing the tubular sleeve 620, the split ring collar 615, and the expansion cone segment assembly 610 in the axial direction away from the expansion cone segment support members 605bb. As a result, the plurality of expansion cone segments 610ba are displaced off of the cylindrical section 605bbc and the conical section 605bbb and back onto the cylindrical section 605bba of the expansion cone segment support members 605bb. Because the collets 610b of the expansion cone segment assembly 610 are resilient, the expansion segments 610ba are thereby returned to a position in which the outside diameter of the plurality of expansion cone segments 610ba is less than or equal to the maximum diameter of the remaining components of the assembly 600.

[000275] In several alternative embodiments, the assembly 600 is incorporated into the assemblies 200, 300 and/or 400, described above with reference to Figs. 1, 1a, 1b, 1c, 1d, 1e, 1f, 1g, 1h 1,i 1j, 1k, 1l, 1m, 2, 2a, 2b, 2c, 2d, 2e, 2f, 2g, 2h, 3, 3a, 3b, 3c, 3d, 3e, 3f, 3g, 3h, 3i, 3j, 4, 4a, 4b, 4c, 4d, 5, 5a, 5b, 5c, 5d, 6, 6a, 6b, 6c, 6d, 6e, 6f, 6g, 6h, 6i, 6j, 6k, 7, 7a, 7b, 7c, 8, 8a, 8b, 8c, and 8d.

[000276] Referring now to Figs. 13, 13a, 13b, 13c, 14 and 14a, an embodiment of an expansion cone assembly 700 will be described. The assembly 700 includes a tubular support member 705 that defines a passage 705a and includes an expansion cone support flange assembly 705b and an end stop 705c. The expansion cone support flange assembly 705b includes a tubular body 705ba and a plurality of substantially identical equally spaced apart expansion cone segment support members 705bb that extend outwardly from the tubular body 705ba in the radial direction. The support members 705bb further include first sections 705bba having arcuate cylindrical outer surfaces, second sections 705bbb having arcuate conical outer surfaces, and third sections 705bbc having arcuate cylindrical outer surfaces for reasons to be described.

[000277] An expansion cone segment assembly 710 is provided that includes a first tubular support 710a defining a passage 710aa for receiving the tubular support member 705 and which includes a slot 710ab, and a second tubular support 710b defining a passage 710ba for receiving the tubular support member 705 and which includes a plurality of spaced apart and substantially identical axial slots 710bb. A plurality of spaced apart and substantially identical resilient expansion cone segment collets 710ac extend from the first tubular support 710a in the axial direction, are received within corresponding axial slots 710bb in the second tubular support 710b, and include substantially identical expansion cone segments 710aca which extend therefrom in the axial direction. A plurality of spaced apart and substantially identical resilient expansion cone segment collets 710bc extend from the

second tubular support 710b in the axial direction, are interleaved and overlap with the expansion cone segment collets 710ac, and include substantially identical expansion cone segments 710bca extending therefrom in the axial direction. Each of the expansion cone segments 710aca and 710bca further include arcuate conical expansion surfaces 710acaa and 710bcaa, respectively, for radially expanding an expandable tubular member. A plurality of pins 715a, 715b, 715c, and 715d couple the expansion cone segment collets 710ac to the second tubular support 710b.

[000278] A split ring collar 720 is provided that defines a passage 720a for receiving the tubular support member 705 and which includes an L-shaped retaining member 720b at one end for mating with the slot 710ab of the first tubular support 710a of the expansion cone segment assembly 710. Another end of the split ring collar 720 includes an L-shaped retaining member 720c. A tubular sleeve 725 is provided that defines a passage 725a for receiving the tubular support member 705 and which includes a slot 725b for receiving the L-shaped retaining member 720c of the split ring collar 720.

[000279] During operation, the assembly 700 begins in an unexpanded position, as illustrated in Figs. 13, 13a, 13b, and 13c, with the expansion cone segments 710aca of the expansion cone segment assembly 710 overlapping with and positioned over the expansion cone segments 710bca of the expansion cone segment assembly 710, positioned adjacent to the base of the conical section 705bbb of the expansion cone segment support members 705bb, with the outside diameter of the expansion cone segments 710aca and 710bca less than or equal to the maximum outside diameter of the assembly 700. As illustrated in Figs. 14 and 14a, the assembly 700 may then be expanded by displacing the tubular sleeve 725, the split ring collar 720, and the expansion cone segment assembly 710 in the axial direction towards the expansion cone segment support members 705bb. As a result, the expansion cone segments 710aca and 710bca are driven up the conical section 705bbb of the expansion cone segment support members 705bb and then onto the cylindrical section 705bbc of the expansion cone segment support members 705bb until the expansion cone segments 710aca and 710bca engage the end stop 705c. In this manner, the outside diameter of the expansion segments 710aca and 710bca is made greater than the maximum diameter of the remaining components of the assembly 700. Furthermore, the conical outer surfaces 710acaa and 710bcaa of the expansion cone segments 710aca and 710bca, respectively, may now be used to radially expand a tubular member. In an exemplary embodiment, the outer conical surfaces 710acaa and 710bcaa of the expansion cone segments 710aca and 710bca, respectively, in the expanded position of the assembly 700 provide a substantially continuous outer conical surfaces in the circumferential direction.

[000280] The assembly 700 may then be returned to the unexpanded position by displacing the tubular sleeve 720, the split ring collar 715, and the expansion cone segment assembly 710 in the axial direction away from the expansion cone segment support members 705bb. As a result, the expansion cone segments 710aca and 710bca are displaced off of the cylindrical section 705bbc and the conical section 705bbb and back onto the cylindrical section 705bba of the expansion cone segment support members 705bb. Because the collets 710ac and 710bc of the expansion cone segment assembly 710 are resilient, the expansion segments 710aca and 710bca are thereby returned to a position in which the outside diameter of the expansion cone segments 710aca and 710bca is less than or equal to the maximum diameter of the remaining components of the assembly 700.

[000281] In several alternative embodiments, the assembly 700 is incorporated into the assemblies 200, 300 and/or 400, described above with reference to Figs. 1, 1a, 1b, 1c, 1d, 1e, 1f, 1g, 1h 1,i 1j, 1k, 1l, 1m, 2, 2a, 2b, 2c, 2d, 2e, 2f, 2g, 2h, 3, 3a, 3b, 3c, 3d, 3e, 3f, 3g, 3h, 3i, 3j, 4, 4a, 4b, 4c, 4d, 5, 5a, 5b, 5c, 5d, 6, 6a, 6b, 6c, 6d, 6e, 6f, 6g, 6h, 6i, 6j, 6k, 7, 7a, 7b, 7c, 8, 8a, 8b, 8c, and 8d.

[000282] Referring to Figs. 15, 15a, 15b, 15c, 15d, 15e, 15f, 15g, 15h, 15i, and 15j, an alternative embodiment of an apparatus 800 for forming a wellbore casing in a subterranean formation will now be described. The apparatus 800 includes a tubular support member 805 defining an internal passage 805a which is coupled to an end of a tubular coupling 810 defining an internal passage 810a. The other end of the tubular coupling 810 is coupled to an end of a tubular support member 815 defining an internal passage 815a having a throat passage 815aa that includes a first radial passage 815b, a first flange 815c having a second radial passage 815d, a second flange 815e having opposite shoulders 815ea and 815eb, a third flange 815f, and an expansion cone support body 815g. The other end of the tubular support member 815 is coupled to a tubular end stop 820 that defines a passage 820a.

[000283] As illustrated in Figs. 15d and 15e, the expansion cone support body 815g includes a first end 815ga, a tapered hexagonal portion 815gb that includes a plurality of T-shaped slots 815gba provided on each of the external faceted surfaces of the tapered hexagonal portion 815gb, and a second end 815gc. In an exemplary embodiment, the angle of attack of the tapered hexagonal portion 815gb ranges from about 35 to 50 degrees for reasons to be described.

[000284] As illustrated in Figs. 15, 15a, 15b, 15c, 15f, 15g, 15h, 15i, and 15j, a plurality of expansion cone segments 825 are provided with each including a first end 825a that includes a T-shaped retaining member 825aa, a second end 825b that includes a T-shaped retaining member 825ba that is operable to mate with and be received within corresponding T-shaped slots 815gba on the tapered hexagonal portion 815gb of the expansion cone support body 815g, a first external surface 825bb, a second external surface 825bc, and a third external surface 825bd. In an exemplary embodiment, a total of six expansion cone segments 825 are provided that are slidably coupled to corresponding sides of the tapered hexagonal portion 815gb of the expansion cone support body 815g.

[000285] In an exemplary embodiment, the width of the first external surface 825bb of each expansion cone segment 825 increases in the direction of the second external surface 825bc, the width of the second external surface 825bc is substantially constant, and the width of the third external surface 825bd decreases in the direction of the first end 825a of each expansion cone segment 825 for reasons to be described. In an exemplary embodiment, the first external surface 825bb of each expansion cone segment 825 tapers upwardly in the direction of the second external surface 825bc, the second external surface 825bc tapers upwardly in the direction of the third external surface 825bd, and the third external surface 825bd tapers downwardly in the direction of the first end 825a of each expansion cone segment 825 for reasons to be described. In an exemplary embodiment, the angle of attack of the taper of the first external surface 825bb of each expansion cone segment 825 is greater than the angle of attack of the taper of the second external surface 825bc. In an exemplary embodiment, the first external surface 825bb and second external surfaces 825bc of each expansion cone segment 825 are arcuate such that when the plurality of expansion cone segments 825 are displaced in the direction of the end stop 420, the first external surface 825bb and second external surfaces 825bc of the plurality expansion cone segments 825 provide a substantially continuous outer circumferential surface for reasons to be described.

[000286] As illustrated in Fig. 15i, in an exemplary embodiment, the external surfaces 825bb, 825bc, and 825bd, of the second ends 825b of the plurality expansion cone segments 825 are adapted to mate with each other in order to interlock adjacent expansion cone segment 825.

[000287] As illustrated in Figs. 15, 15c, and 15j, a split ring collar 830 that defines a passage 830a for receiving the tubular support member 815 and includes a first end with a plurality of T-shaped slots 830b for receiving and mating with corresponding T-shaped retaining members 825aa of the plurality of expansion cone segments 825 and a second end that includes an L-shaped retaining member 830c. In an exemplary embodiment, the split ring collar

830 is a conventional split ring collar commercially available from Halliburton Energy Services modified in accordance with the teachings of the present disclosure.

[000288] A dog assembly 835 is provided that includes a tubular sleeve 835a which defines a passage 835aa for receiving the tubular support member 815, and includes a slot 835ab for receiving and mating with the L-shaped retaining member 830c of the split ring collar 830, a counterbore 835ac, and a radial passage 835ad. An end of a load transfer pin 835b passes through the radial passage 835ad and is coupled to a retaining ring 835c which defines a passage 835ca for receiving the flange 815f of the tubular support member 815 and which is received within the counterbore 835ac of the tubular sleeve 835a. A ring 835d that defines a passage 835da for receiving the tubular support member 815 and a spring 835e are also received within the counterbore 835ac of the tubular sleeve 835a between the flange 815f and the end of the counterbore 835ac. The other end of the load transfer pin 835b is coupled to an end of a tubular sleeve 835f which includes a counterbore 835fa for receiving the tubular sleeve 835a, a radial passage 835fb for receiving a conventional resilient dog 835g, a counterbore 835fc for receiving and mating with the flange 815e of the tubular support member 815, a flange 835fd, a flange 835fe including counterbores 835ff and 835fg that mate with and receive the flange 815c of the tubular support member 815, and a radial passage 835fh.

[000289] A first conventional packer cup assembly 840 that defines a passage 440a for receiving the tubular sleeve 835f includes a first end 840b that mates with the flange 835fd of the tubular sleeve 835f, a conventional sealing cup 840c, and a second end 840d. A tubular spacer 845 that defines a passage 845a for receiving the tubular sleeve 835f includes a first end 845b that mates with the second end 840d of the first packer cup assembly 840 and a second end 845c. A second conventional packer cup assembly 850 that defines a passage 850a for receiving the tubular sleeve 835f includes a first end 850b that mates with the second end 845c of the spacer 845, a conventional sealing cup 850c, and a second end 850d that mates with the flange 835fe of the tubular sleeve 835f.

[000290] In an exemplary embodiment, during operation of the apparatus 800, as illustrated in Figs. 15, 15a, 15b, 15c, 15d, 15e, 15f, 15g, 15h, 15i, and 15j, the apparatus 800 may be initially positioned in the wellbore 100, within the casing 110, with the dog assembly 835 positioned in a neutral position in which the radial passage 815d of the tubular support member 815 is fluidicly coupled to the radial passage 835fh of the dog assembly 835 and the plurality of expansion cone segments 825 are not driven up the tapered hexagonal portion 815gb of the expansion cone support body 815g of the tubular support member 815 into contact with the stop member 320. In this manner, fluidic materials within the interior 815a of the tubular support member 815 may pass through the radial passages 815d and 835fh and into the annulus between the apparatus 800 and the casing 110, thereby preventing over pressurization of the annulus. Furthermore, in this manner, the outside diameter of the plurality of expansion cone segments 825 is less than or equal to the outside diameter of the stop member 820, thereby permitting the apparatus 800 to be displaced within the casing 110.

[000291] As illustrated in Figs. 16, 16a, 16b, and 16c, the apparatus 800 may then be positioned in the tubular member 120. During the insertion of the apparatus 800 into the tubular member 120, the upper end 120b of the tubular member 120 may engage the end of the resilient dog 835g of the dog assembly 835 thereby driving the resilient dog 835g backwards onto the shoulder 815ea of the flange 815e of the tubular support member 815. As a result of the backward axial displacement of the resilient dog 835g, the tubular sleeve 835f, the pin 835b, the retaining ring 835c, the ring 835d, and the spring 835e of the dog assembly 835 are driven backward thereby compressing the spring 835e and applying an axial biasing force to the tubular sleeve 835a that prevents the plurality of expansion cone segments 825 from being displaced toward the end stop 820.

[000292] The apparatus 800 may then be at least partially positioned in the open hole section 115a of the wellbore section 115, beyond the lower end 120c of the tubular member 120. In an exemplary embodiment, that portion of the apparatus 800 that includes the stop member 820, the plurality of expansion cone segments 825, the split ring collar 830, and the dog assembly 835 is then positioned in the open hole section 115a of the wellbore section 115, beyond the lower end 120c of the tubular member 120 for reasons to be described. Because the dog 835g of the dog assembly 835 is resilient, once the apparatus 800 has been positioned in the open hole section 115a of the wellbore section 115, beyond the lower end 120c of the tubular member 120, the resilient dog 835g of the dog assembly 835 may spring outwardly in the radial direction.

[000293] The apparatus 800 may then be repositioned at least partially back within the tubular member 120. During the re-insertion of the apparatus 800 into the tubular member 120, the lower end 120c of the tubular member 120 may impact the ends of the resilient dog 835g of the dog assembly 835, thereby driving the resilient dog 835g forward until the resilient dog 835g is positioned onto the shoulder 815eb of the flange 815e of the tubular support member 815.

[000294] As a result of the forward axial displacement of the resilient dog 835g, the tubular sleeve 835f, the spring 835e, the ring 835d, the ring 835c, the pin 835b, and the tubular sleeve 835a are displaced in the forward axial direction, thereby displacing the split ring collar 830 and the plurality of expansion cone segments 825 in the forward axial direction. As a result, the plurality of expansion cone segments 825 are driven up the tapered hexagonal portion 815gb of the expansion cone support body 815g of the tubular support member 815 and into contact with the stop member 320. Furthermore, as a result of the forward axial displacement of the tubular sleeve 835f, the radial passages 815d and 835fh are fluidicly decoupled. As a result, fluidic materials within the tubular support member 815 may not pass into the annulus between the tubular support member and the tubular member 120.

[000295] As a result of the forward axial displacement of the resilient dog 435e, the outside diameter of the plurality of expansion cone segments 825 is made greater than the inside diameter of expandable tubular member 120, thereby permitting the apparatus 800 to be used to radially expand and plastically deform the tubular member 120, and fluidic materials within the interior 815a of the tubular support member 815 may no longer pass through the radial passages 815d and 935fh and into the annulus between the apparatus 800 and the tubular member 120, thereby permitting the interior of the apparatus 800 to be pressurized.

[000296] The apparatus 800 may then be operated to radially expand and plastically deform the tubular member 120 by applying an upward axial force to the tubular support member 815 and/or by injecting a pressurized fluidic material into the tubular support member 815.

[000297] In particular, as illustrated in Figs. 17, 17a, 17b, and 17c, the expandable tubular member 120 may then be radially expanded using the apparatus 800 by injecting a fluidic material 275 into the apparatus 800 through the passages 805a, 810a, 815a, and 820a. The injection of the fluidic material 275 may pressurize the interior 120a of the expandable tubular member 120. In addition, because the packer cup assemblies 840 and 850 seal off an annular region 120aa below the packer cup assemblies 840 and 850 located between the expandable tubular member 120 and the tubular support member 815, the injection of the fluidic material 275 may also pressurize the annular region 120aa.

[000298] The continued injection of the fluidic material 275 may then pressurize the interior 120a of the expandable tubular member 120 thereby plastically deforming and radially expanding the expandable tubular member 120 off of the plurality of expansion cone segments 825. Because the outer surfaces 825bb and 825bc of

the plurality of expansion cone segments 825 are tapered, the plastic deformation and radial expansion of the expandable tubular member 120 proximate the plurality of expansion cone segments 825 is facilitated. Furthermore, in an exemplary embodiment, the continued injection of the fluidic material 275 also pressurizes the annular region 120aa defined between the interior surface of the expandable tubular member 120 and the exterior surface of the tubular support member 815 which is bounded on the upper end by the packer cup assembly 840 and on the lower end by the plurality of expansion cone segments 825. Furthermore, in an exemplary embodiment, the pressurization of the annular region 120aa also radially expands at least a portion of the surrounding portion of the expandable tubular member 120. In this manner, the plastic deformation and radial expansion of the expandable tubular member 120 is enhanced. Furthermore, during operation of the apparatus 300, the packer cup assemblies 840 and 850 prevent the pressurized fluidic material 275 from passing above and beyond the packer cup assemblies 840 and 850 and thereby define the length of the pressurized annular region 120aa. In an exemplary embodiment, the pressurization of the annular region 120aa decreases the operating pressures required for plastic deformation and radial expansion of the expandable tubular member 120 by as much as 50% and also reduces the angle of attack of the tapered external surfaces 825bb and 825bc of the plurality of expansion cone segments 825.

[000299] The radial expansion of the expandable tubular member 120 may then continue until the upper end 120b of the expandable tubular member 120 is radially expanded and plastically deformed along with the overlapping portion of the wellbore casing 110. Because the plurality of expansion cone segments 825 may be adjustably positioned from an outside diameter which is less than the inside diameter of the expandable tubular member 120 to an outside diameter which is substantially equal to the inside diameter of the pre-existing casing 110, the resulting wellbore casing, including the casing 110 and the radially expanded tubular member 120, which is created by the operation of the apparatus 800 may have a single substantially constant inside diameter, thereby providing a mono-diameter wellbore casing.

[000300] During the radial expansion process, the plurality of expansion cone segments 825 may be raised out of the expanded portion of the tubular member 120 by applying an upward axial force to the tubular support member 815. In a preferred embodiment, during the radial expansion process, the plurality of expansion cone segments 825 are raised at approximately the same rate as the tubular member 120 is expanded in order to keep the tubular member 120 stationary relative to the new wellbore section 115.

[000301] In a preferred embodiment, when the upper end portion of the expandable tubular member 120 and the lower portion of the wellbore casing 110 that overlap with one another are plastically deformed and radially expanded by the plurality of expansion cone segments 825. The plurality of expansion cone segments 825 may be displaced out of the wellbore 100 by both the operating pressure within the interior of the tubular member 120 and a upwardly directed axial force applied to the tubular support member 805.

[000302] In a preferred embodiment, the operating pressure and flow rate of the fluidic material 275 is controllably ramped down when the plurality of expansion cone segments 825 reach the upper end portion of the expandable tubular member 120. In this manner, the sudden release of pressure caused by the complete radial expansion and plastic deformation of the expandable tubular member 120 off of the expansion cone segments 825 can be minimized. In a preferred embodiment, the operating pressure is reduced in a substantially linear fashion from 100% to about 10% during the end of the extrusion process beginning when the plurality of expansion cone segments 825 are within about 5 fect from completion of the extrusion process.

[000303] Alternatively, or in combination, the wall thickness of the upper end portion of the expandable tubular member 120 is tapered in order to gradually reduce the required operating pressure for plastically deforming and

radially expanding the upper end portion of the tubular member 120. In this manner, shock loading of the apparatus 800 is reduced.

[000304] Alternatively, or in combination, a shock absorber is provided in the tubular support member 805 in order to absorb the shock caused by the sudden release of pressure. The shock absorber may comprise, for example, any conventional commercially available shock absorber, bumper sub, or jars adapted for use in wellbore operations.

[000305] Alternatively, or in combination, an expansion cone catching structure is provided in the upper end portion of the expandable tubular member 120 in order to catch or at least decelerate the expansion cone segments 825.

[000306] Alternatively, or in combination, during the radial expansion process, an upward axial force is applied to the tubular support member 815 sufficient to plastically deform and radially expand the tubular member 120 off of the external surfaces 225bb and 225bc of the plurality of expansion cone segments 825.

[000307] Alternatively, or in combination, in order to facilitate the pressurization of the interior 120a of the expandable tubular member 120 by the injection of the fluidic materials 275, the region within the wellbore section 115 below the apparatus 800 may be fluidicly sealed off in a convention manner using, for example, a packer.

[000308] Once the radial expansion process is completed, the tubular support member 805, the tubular support member 810, the tubular support member 815, the end stop 820, the plurality of expansion cone segments 825, the split ring collar 830, the dog assembly 835, the packer cup assembly 840, the spacer 845, and the packer cup assembly 850 are removed from the wellbores 100 and 115.

[000309] If the expansion cone segments 825 become lodged within the expandable tubular member 120 during the radial expansion process, then a ball 280 may be placed in the throat 815aa of the passage 815a of the tubular support member 815. The continued injection of the fluidic material 275 following the placement of the ball 280 in the throat 815aa of the passage 815a of the tubular support member will then pressurize the radial passage 815b and an annular portion 835fga of the counterbore 835fg. As a result of the pressurization of the annular portion 835fga of the counterbore 835fg, the tubular sleeve 835f, the pin 835b, the retaining ring 835c, the ring 835d, the spring 835e, the tubular sleeve 835a of the dog assembly 835, and the split ring collar 830 are driven backward thereby displacing the plurality of expansion cone segments 825 backwards in the axial direction away from the end stop 820. In this manner, the outside diameter of the plurality of expansion cone segments 825 is thereby reduced and the apparatus 800 may then be removed from the expandable tubular member 120.

[000310] Referring now to Figs. 18a, 18b, 18c, and 18d, an embodiment of an expansion cone assembly 900 will be described. The assembly 900 includes a tubular support member 905 that defines a passage 905a and includes an expansion cone support flange assembly 905b which is coupled to an end stop 910 that defines a passage 910a. The expansion cone support flange assembly 905b includes a first tubular end 905ba, a second tubular end 905bb, and an intermediate hexagonal conical tubular body 905bc that includes a plurality of substantially identical and equally spaced apart expansion cone segment support slots 905bcaa, 905bcab, 905bcac, 905bcad, 905bcae, and 905bcaf on each of the facets of the hexagonal tubular body.

[000311] A plurality of first expansion cone segments 915a, 915b, and 915c are provided that include T-shaped retaining members 915aa, 915ba, and 915ca, respectively, which are operable to mate with and are movably received within the T-shaped slots 905bcaa, 905bcac, and 905bcae of the hexagonal conical tubular body 905bc of the expansion cone support assembly 905b. The plurality of first expansion cone segments 915aa, 915ba, and 915ca also each include a T-shaped retaining member 915ab, 915bb, and 915cb, respectively, an exterior top

surface 915ac, 915bc, and 915cc, respectively, an exterior top surface 915ad, 915bd, and 915cd, respectively, an exterior top surface 915ae, 915be, and 915ce, respectively, an exterior top surface 915af, 915bf, and 915cf, respectively, and an exterior top surface 915ag, 915bg, and 915cg, respectively. In an exemplary embodiment, the exterior top surfaces 915ac, 915bc, and 915cc and the exterior top surfaces 915ad, 915bd, and 915cd are arcuate conical surfaces in which the angle of attack of the exterior top surfaces 915ac, 915bc, and 915cc is greater than the angle of attack of the exterior top surfaces 915ad, 915bd, and 915cd.

[000312] A plurality of second expansion cone segments 920a, 920b, and 920c, which are interleaved with and complementary shaped to the first expansion cone segments 915a, 915b, and 915c, are also provided. Each of the plurality of second expansion cone segments 902a, 920b, and 920c include a T-shaped retaining members 920aa, 920ba, and 920ca, respectively, that is operable to mate with and is movably received within the T-shaped slots 905bcab, 905bcad, and 905bcaf, respectively, of the hexagonal conical tubular body 905bc of the expansion cone support assembly 905b. Each of the plurality of second expansion cone segments 902a, 920b, and 920c also include a T-shaped retaining member 920ab, 902bb, and 920cb, respectively, an exterior top surface 920ac, 920bc, and 920cc, respectively, an exterior top surface 920ad, 920bd, and 920cd, respectively, an exterior top surface 920ae, 920be, and 920ce, respectively, an exterior top surface 920af, 920bf, and 920cf, respectively, and an exterior top surface 920ag, 920bg, and 920cg. In an exemplary embodiment, the exterior top surfaces 920ac, 920bc, and 920cc and the exterior top surfaces 920ad, 920bd, and 920cd are arcuate conical surfaces in which the angle of attack of the exterior top surfaces 920ac, 920bc, and 920cc is greater than the angle of attack of the exterior top surfaces 920ad, 920bd, and 920cd.

[000313] A split ring collar 925 is provided which defines a passage 925a for receiving the tubular support member 905 and which includes an L-shaped retaining member 925b at one end of the split ring collar 925 and T-shaped slots, 925c, 925d, 925e, 925f, 925g, and 925h, at another end of the split ring collar which are operable to mate with and receive the T-shaped retaining members, 915ab, 920ab, 915bb, 920bb, 915cb, and 920cb, of the expansion cone segments, 915a, 920a, 915b, 920b, 915c, and 920c, respectively. A tubular sleeve 930 is provided that defines a passage 930a for receiving the tubular support member 905 and which includes a slot 930b for receiving and mating with the L-shaped retaining member 925b of the split ring collar 925.

[000314] During operation, the assembly 900 begins in an unexpanded position, as illustrated in Figs. 18a, 18b, 18c, and 18d, with the expansion cone segments 915a, 915b, 915c, 915d, 920a, 920b, 920c, and 920d positioned adjacent to the base of the hexagonal conical tubular body 905bc of the expansion cone support flange 905b and away from the end stop 910. In this manner, the outside diameter of the expansion cone segments 915a, 915b, 915c, 915d, 920a, 920b, 920c, and 920d is less than or equal to the maximum outside diameter of the assembly 900. Furthermore, in the unexpanded position, the expansion cone segments, 915a, 915b, and 915c, are positioned further away from the end stop 910 than the expansion cone segments, 920a, 920b, and 920c.

[000315] As illustrated in Figs. 19 and 19a, the assembly 900 may then be expanded by displacing the tubular sleeve 930 and the split ring collar 925 in the axial direction towards the expansion cone segment support members 705bb. As a result, the expansion cone segments 915a, 915b, 915c, 920a, 920b, and 920c, are driven up the hexagonal conical tubular body 905bc of the expansion cone support flange 905b until the expansion cone segments 915a, 915b, 915c, 920a, 920b, and 920c engage the end stop 910. In this manner, the outside diameter of the expansion cone segments 915a, 915b, 915c, 920a, 920b, and 920c, is greater than the maximum diameter of the remaining components of the assembly 900. Furthermore, the conical outer surfaces 915ac, 915bc, 915cc, 920ac, 920bc, and 920cc, and the conical outer surfaces 915ad, 915bd, 915cd, 920ad, 920bd, and 920cd, of the expansion

cone segments 915a, 915b, 915c, 920a, 920b, and 920c, respectively, may now be used to radially expand a tubular member. In an exemplary embodiment, the outer conical surfaces 915ac, 915bc, 915cc, 920ac, 920bc, and 920cc, and the conical outer surfaces 915ad, 915bd, 915cd, 920ad, 920bd, and 920cd, of the expansion cone segments 915a, 915b, 915c, 920a, 920b, and 920c, respectively, in the expanded position of the assembly 900, provide a substantially continuous outer conical surfaces in the circumferential direction. Furthermore, note that in the expanded position of the assembly 900, the first set of expansion cone segments 915a, 915b, and 915c, are brought into alignment with the second set of expansion cone segments 920a, 920b, and 920c.

[000316] The assembly 900 may then be returned to the unexpanded position by displacing the tubular sleeve 930 and the split ring collar 925 in the axial direction away from the end stop 910. As a result, the expansion cone segments 915a, 915b, 915c, 920a, 920b, and 920c, are displaced away from the end stop 910, down the conical hexagonal tubular member 905bc and are returned to a position in which the outside diameter of the expansion cone segments 915a, 915b, 915c, 920a, 920b, and 920c is less than or equal to the maximum diameter of the remaining components of the assembly 900.

[000317] In several alternative embodiments, the assembly 900 is incorporated into the assemblies 200, 300, 400, and 800 described above with reference to Figs. 1, 1a, 1b, 1c, 1d, 1e, 1f, 1g, 1h 1,i 1j, 1k, 1l, 1m, 2, 2a, 2b, 2c, 2d, 2e, 2f, 2g, 2h, 3, 3a, 3b, 3c, 3d, 3e, 3f, 3g, 3h, 3i, 3j, 4, 4a, 4b, 4c, 4d, 5, 5a, 5b, 5c, 5d, 6, 6a, 6b, 6c, 6d, 6e, 6f, 6g, 6h, 6i, 6j, 6k, 7, 7a, 7b, 7c, 8, 8a, 8b, 8c, 8d, 15, 15a, 15b, 15c, 15d, 15e, 15f, 15g, 15h, 15i, 15j, 16, 16a, 16b, 16c, 17, 17a, 17b, and 17c.

[000318] Referring to Fig. 20a, an embodiment of an expansion cone segment assembly 1000 includes interlocking expansion cone segments, 1000a, 1000b, 1000c, 1000d, 1000e, and 1000f.

[000319] Referring to Fig. 20b, an embodiment of an expansion cone segment assembly 1100 includes interlocking expansion cone segments, 1100a, 1100b, 1100c, 1100d, 1100e, and 1100f.

[000320] Referring to Fig. 20c, an embodiment of an expansion cone segment assembly 1200 includes interlocking expansion cone segments, 1200a, 1200b, 1200c, 1200d, 1200e, and 1200f.

[000321] Referring to Fig. 20d, an embodiment of an expansion cone segment assembly 1300 includes interlocking expansion cone segments, 1300a, 1300b, 1300c, 1300d, 1300e, and 1300f.

[000322] Referring to Fig. 20e, an embodiment of an expansion cone segment assembly 1400 includes interlocking expansion cone segments, 1400a, 1400b, 1400c, 1400d, 1400e, and 1400f.

[000323] Referring to Fig. 20f, an embodiment of an expansion cone segment assembly 1500 includes interlocking expansion cone segments, 1500a, 1500b, 1500c, 1500d, 1500e, and 1500f.

[000324] Referring to Fig. 20g, an embodiment of an expansion cone segment assembly 1600 includes interlocking expansion cone segments, 1600a, 1600b, 1600c, 1600d, 1600e, and 1600f.

[000325] Referring to Fig. 20h, an embodiment of an expansion cone segment assembly 1700 includes interlocking expansion cone segments, 1700a, 1700b, 1700c, 1700d, 1700e, and 1700f.

[000326] Referring to Fig. 20i, an embodiment of an expansion cone segment assembly 1800 includes interlocking expansion cone segments, 1800a, 1800b, 1800c, 1800d, 1800e, and 1800f.

[000327] Referring to Fig. 20j, an embodiment of an expansion cone segment assembly 1900 includes interlocking expansion cone segments, 1900a, 1900b, 1900c, 1900d, 1900e, and 1900f.

[000328] Referring to Fig. 20k, an embodiment of an expansion cone segment assembly 2000 includes interlocking expansion cone segments, 2000a, 2000b, 2000c, 2000d, 2000e, and 2000f.

[000329] Referring to Fig. 20l, an embodiment of an expansion cone segment assembly 2100 includes interlocking expansion cone segments, 2100a, 2100b, 2100c, 2100d, 2100e, and 2100f.

[000330] Referring to Fig. 20m, an embodiment of an expansion cone segment assembly 2200 includes interlocking expansion cone segments, 2200a, 2200b, 2200c, 2200d, 2200e, and 2200f.

[000331] The expansion cone segment assemblies 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, and 2200 provide enhanced operational properties such as, for example, efficient radial expansion of expandable tubular members and durability during operation.

[000332] In several alternative embodiments, the design and operational features of the apparatus 200, 300, 400, and 800, and the assembly 500, 600, 700, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, and 2200 may be combined, in whole or in part, and/or the design and operational elements of the apparatus 200, 300, 400, and 800, and the assembly 500, 600, 700, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, and 2200 may be interspersed among each other.

[000333] In several alternative embodiments, the apparatus 200, 300, 400, and 800, and the assembly 500, 600, 700, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, and 2200 may be used to form or repair wellbore casings, pipelines, or structural supports.

[000334] In several alternative embodiments, the apparatus 200, 300, 400, and 800, and the assembly 500, 600, 700, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, and 2200 include two or more expansion cone segments that may be movably support and guided on a tapered expansion cone support body that may, for example, be conical, or may be a multi-sided body.

[000335] In several alternative embodiments, the design and operation of the apparatus 200, 300, 400, and 800, and the assembly 500, 600, 700, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, and 2200 are provided substantially as disclosed in one or more of the following: (1) U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, which claims priority from provisional application 60/121,702, filed on 2/25/99, (3) U.S. Patent Number 6,823,937, which was filed as U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, which claims priority from provisional application 60/119,611, filed on 2/11/99, (4) U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (5) U.S. patent application serial no. 10/169,434, attorney docket no. 25791.10.04, filed on 7/1/02, which claims priority from provisional application 60/183,546, filed on 2/18/00, (6) U.S. patent no. 6,640,903 which was filed as U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (7) U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (8) U.S. patent number 6,575,240, which was filed as patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, which claims priority from provisional application 60/121,907, filed on 2/26/99, (9) U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (10) U.S. patent application serial no. 09/981,916, attorney docket no. 25791.18, filed on 10/18/01 as a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent

Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (11) U.S. patent number 6,604,763, which was filed as application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, which claims priority from provisional application 60/131,106, filed on 4/26/99, (12) U.S. patent application serial no. 10/030,593, attorney docket no. 25791.25.08, filed on 1/8/02, which claims priority from provisional application 60/146,203, filed on 7/29/99, (13) U.S. provisional patent application serial no. 60/143,039, attorney docket no. 25791.26, filed on 7/9/99, (14) U.S. patent application serial no. 10/111,982, attorney docket no. 25791.27.08, filed on 4/30/02, which claims priority from provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (15) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (16) U.S. provisional patent application serial no. 60/438,828, attorney docket no. 25791.31, filed on 1/9/03, (17) U.S. patent number 6,564,875, which was filed as application serial no. 09/679,907, attorney docket no. 25791.34.02, on 10/5/00, which claims priority from provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (18) U.S. patent application serial no. 10/089,419, filed on 3/27/02, attorney docket no. 25791.36.03, which claims priority from provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (19) U.S. patent application serial no. 09/679,906, filed on 10/5/00, attorney docket no. 25791.37.02, which claims priority from provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (20) U.S. patent application serial no. 10/303,992, filed on 11/22/02, attorney docket no. 25791.38.07, which claims priority from provisional patent application serial no. 60/212,359, attorney docket no. 25791.38, filed on 6/19/2000, (21) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (22) U.S. provisional patent application serial no. 60/455,051, attorney docket no. 25791.40, filed on 3/14/03, (23) PCT application US02/2477, filed on 6/26/02, attorney docket no. 25791.44.02, which claims priority from U.S. provisional patent application serial no. 60/303,711, attorney docket no. 25791.44, filed on 7/6/01, (24) U.S. patent application serial no. 10/311,412, filed on 12/12/02, attorney docket no. 25791.45.07, which claims priority from provisional patent application serial no. 60/221,443, attorney docket no. 25791.45, filed on 7/28/2000, (25) U.S. patent application serial no. 10/, filed on 12/18/02, attorney docket no. 25791.46.07, which claims priority from provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (26) U.S. patent application serial no. 10/322,947, filed on 1/22/03, attorney docket no. 25791.47.03, which claims priority from provisional patent application serial no. 60/233,638, attorney docket no. 25791.47, filed on 9/18/2000, (27) U.S. patent application serial no. 10/406,648, filed on 3/31/03, attorney docket no. 25791.48.06, which claims priority from provisional patent application serial no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, (28) PCT application US02/04353, filed on 2/14/02, attorney docket no. 25791.50.02, which claims priority from U.S. provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on 2/20/2001, (29) U.S. patent application serial no. 10/465,835, filed on 6/13/03, attorney docket no. 25791.51.06, which claims priority from provisional patent application serial no. 60/262,434, attorney docket no. 25791.51, filed on 1/17/2001, (30) U.S. patent application serial no. 10/465,831, filed on 6/13/03, attorney docket no. 25791.52.06, which claims priority from U.S. provisional patent application serial no. 60/259,486, attorney docket no. 25791.52, filed on 1/3/2001, (31) U.S. provisional patent application serial no. 60/452,303, filed on 3/5/03, attorney docket no. 25791.53, (32) U.S. patent number 6,470,966, which was filed as patent application serial number 09/850,093, filed on 5/7/01, attorney docket no. 25791.55, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from

provisional application 60/111,293, filed on 12/7/98, (33) U.S. patent number 6,561,227, which was filed as patent application serial number 09/852,026 , filed on 5/9/01, attorney docket no. 25791.56, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (34) U.S. patent application serial number 09/852,027, filed on 5/9/01, attorney docket no. 25791.57, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (35) PCT Application US02/25608, attorney docket no. 25791.58.02, filed on 8/13/02, which claims priority from provisional application 60/318,021, filed on 9/7/01, attorney docket no. 25791.58, (36) PCT Application US02/24399, attorney docket no. 25791.59.02, filed on 8/1/02, which claims priority from U.S. provisional patent application serial no. 60/313,453, attorney docket no. 25791.59, filed on 8/20/2001, (37) PCT Application US02/29856, attorney docket no. 25791.60.02, filed on 9/19/02, which claims priority from U.S. provisional patent application serial no. 60/326,886, attorney docket no. 25791.60, filed on 10/3/2001, (38) PCT Application US02/20256, attorney docket no. 25791.61.02, filed on 6/26/02, which claims priority from U.S. provisional patent application serial no. 60/303,740, attorney docket no. 25791.61, filed on 7/6/2001, (39) U.S. patent application serial no. 09/962,469, filed on 9/25/01, attorney docket no. 25791.62, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99, (40) U.S. patent application serial no. 09/962,470, filed on 9/25/01, attorney docket no. 25791.63, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99, (41) U.S. patent application serial no. 09/962,471, filed on 9/25/01, attorney docket no. 25791.64, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99, (42) U.S. patent application serial no. 09/962,467, filed on 9/25/01, attorney docket no. 25791.65, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99, (43) U.S. patent application serial no. 09/962,468, filed on 9/25/01, attorney docket no. 25791.66, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99, (44) PCT application US 02/25727, filed on 8/14/02, attorney docket no. 25791.67.03, which claims priority from U.S. provisional patent application serial no. 60/317,985, attorney docket no. 25791.67, filed on 9/6/2001, and U.S. provisional patent application serial no. 60/318,386, attorney docket no. 25791.67.02, filed on 9/10/2001, (45) PCT application US 02/39425, filed on 12/10/02, attorney docket no. 25791.68.02, which claims priority from U.S. provisional patent application serial no. 60/343,674 , attorney docket no. 25791.68, filed on 12/27/2001, (46) U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, (now U.S. Patent 6,634,431 which issued 10/21/2003), which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (47) U.S. utility patent application serial no. 10/516,467, attorney docket no. 25791.70, filed on 12/10/01, which is a continuation application of U.S. utility

patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, (now U.S. Patent 6,634,431 which issued 10/21/2003), which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (48) PCT application US 03/00609, filed on 1/9/03, attorney docket no. 25791.71.02, which claims priority from U.S. provisional patent application serial no. 60/357,372 , attorney docket no. 25791.71, filed on 2/15/02, (49) U.S. patent application serial no. 10/074,703, attorney docket no. 25791.74, filed on 2/12/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (50) U.S. patent application serial no. 10/074,244, attorney docket no. 25791.75, filed on 2/12/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (51) U.S. patent application serial no. 10/076,660, attorney docket no. 25791.76, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (52) U.S. patent application serial no. 10/076,661, attorney docket no. 25791.77, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (53) U.S. patent application serial no. 10/076,659, attorney docket no. 25791.78, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (54) U.S. patent application serial no. 10/078,928, attorney docket no. 25791.79, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (55) U.S. patent application serial no. 10/078,922, attorney docket no. 25791.80, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (56) U.S. patent application serial no. 10/078,921, attorney docket no. 25791.81, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (57) U.S. patent application serial no. 10/261,928, attorney docket no. 25791.82, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (58) U.S. patent application serial no. 10/079,276, attorney docket no. 25791.83, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (59) U.S. patent application serial no. 10/262,009, attorney docket no. 25791.84, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (60) U.S. patent application serial no. 10/092,481, attorney docket no. 25791.85, filed on 3/7/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney

docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (61) U.S. patent application serial no. 10/261,926, attorney docket no. 25791.86, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (62) PCT application US 02/36157, filed on 11/12/02, attorney docket no. 25791.87.02, which claims priority from U.S. provisional patent application serial no. 60/338,996, attorney docket no. 25791.87, filed on 11/12/01, (63) PCT application US 02/36267, filed on 11/12/02, attorney docket no. 25791.88.02, which claims priority from U.S. provisional patent application serial no. 60/339,013, attorney docket no. 25791.88, filed on 11/12/01, (64) PCT application US 03/11765, filed on 4/16/03, attorney docket no. 25791.89.02, which claims priority from U.S. provisional patent application serial no. 60/383,917, attorney docket no. 25791.89, filed on 5/29/02, (65) PCT application US 03/15020, filed on 5/12/03, attorney docket no. 25791.90.02, which claims priority from U.S. provisional patent application serial no. 60/391,703, attorney docket no. 25791.90, filed on 6/26/02, (66) PCT application US 02/39418, filed on 12/10/02, attorney docket no. 25791.92.02, which claims priority from U.S. provisional patent application serial no. 60/346,309, attorney docket no. 25791.92, filed on 1/7/02, (67) PCT application US 03/06544, filed on 3/4/03, attorney docket no. 25791.93.02, which claims priority from U.S. provisional patent application serial no. 60/372,048, attorney docket no. 25791.93, filed on 4/12/02, (68) U.S. patent application serial no. 10/331,718, attorney docket no. 25791.94, filed on 12/30/02, which is a divisional U.S. patent application serial no. 09/679,906, filed on 10/5/00, attorney docket no. 25791.37.02, which claims priority from provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (69) PCT application US 03/04837, filed on 2/29/03, attorney docket no. 25791.95.02, which claims priority from U.S. provisional patent application serial no. 60/363,829, attorney docket no. 25791.95, filed on 3/13/02, (70) U.S. patent application serial no. 10/261,927, attorney docket no. 25791.97, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (71) U.S. patent application serial no. 10/262,008, attorney docket no. 25791.98, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (72) U.S. patent application serial no. 10/261,925, attorney docket no. 25791.99, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (73) U.S. patent application serial no. 10/199,524, attorney docket no. 25791.100, filed on 7/19/02, which is a continuation of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (74) PCT application US 03/10144, filed on 3/28/03, attorney docket no. 25791.101.02, which claims priority from U.S. provisional patent application serial no. 60/372,632, attorney docket no. 25791.101, filed on 4/15/02, (75) U.S. provisional patent application serial no. 60/412,542, attorney docket no. 25791.102, filed on 9/20/02, (76) PCT application US 03/14153, filed on 5/6/03, attorney docket no. 25791.104.02, which claims priority from U.S. provisional patent application serial no. 60/380,147, attorney docket no. 25791.104, filed on 5/6/02, (77) PCT application US 03/19993, filed on 6/24/03, attorney docket no. 25791.106.02, which claims priority from U.S. provisional patent application serial no. 60/397,284, attorney docket no. 25791.106, filed on 7/19/02, (78) PCT application US 03/13787, filed on 5/5/03, attorney docket no. 25791.107.02, which claims

priority from U.S. provisional patent application serial no. 60/387,486, attorney docket no. 25791.107, filed on 6/10/02, (79) PCT application US 03/18530, filed on 6/11/03, attorney docket no. 25791.108.02, which claims priority from U.S. provisional patent application serial no. 60/387,961, attorney docket no. 25791.108, filed on 6/12/02, (80) PCT application US 03/20694, filed on 7/1/03, attorney docket no. 25791.110.02, which claims priority from U.S. provisional patent application serial no. 60/398,061, attorney docket no. 25791.110, filed on 7/24/02, (81) PCT application US 03/20870, filed on 7/2/03, attorney docket no. 25791.111.02, which claims priority from U.S. provisional patent application serial no. 60/399,240, attorney docket no. 25791.111, filed on 7/29/02, (82) U.S. provisional patent application serial no. 60/412,487, attorney docket no. 25791.112, filed on 9/20/02, (83) U.S. provisional patent application serial no. 60/412,488, attorney docket no. 25791.114, filed on 9/20/02, (84) U.S. patent application serial no. 10/280,356, attorney docket no. 25791.115, filed on 10/25/02, which is a continuation of U.S. patent number 6,470,966, which was filed as patent application serial number 09/850,093, filed on 5/7/01, attorney docket no. 25791.55, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (85) U.S. provisional patent application serial no. 60/412,177, attorney docket no. 25791.117, filed on 9/20/02, (86) U.S. provisional patent application serial no. 60/412,653, attorney docket no. 25791.118, filed on 9/20/02, (87) U.S. provisional patent application serial no. 60/405,610, attorney docket no. 25791.119, filed on 8/23/02, (88) U.S. provisional patent application serial no. 60/405,394, attorney docket no. 25791.120, filed on 8/23/02, (89) U.S. provisional patent application serial no. 60/412,544, attorney docket no. 25791.121, filed on 9/20/02, (90) PCT application US 03/24779, filed on 8/8/03, attorney docket no. 25791.125.02, which claims priority from U.S. provisional patent application serial no. 60/407,442, attorney docket no. 25791.125, filed on 8/30/02, (91) U.S. provisional patent application serial no. 60/423,363, attorney docket no. 25791.126, filed on 12/10/02, (92) U.S. provisional patent application serial no. 60/412,196, attorney docket no. 25791.127, filed on 9/20/02, (93) U.S. provisional patent application serial no. 60/412,187, attorney docket no. 25791.128, filed on 9/20/02, (94) U.S. provisional patent application serial no. 60/412,371, attorney docket no. 25791.129, filed on 9/20/02, (95) U.S. patent application serial no. 10/382,325, attorney docket no. 25791.145, filed on 3/5/03, which is a continuation of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (96) U.S. patent application serial no. 10/624,842, attorney docket no. 25791.151, filed on 7/22/03, which is a divisional of U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, which claims priority from provisional application 60/119,611, filed on 2/11/99, (97) U.S. provisional patent application serial no. 60/431,184, attorney docket no. 25791.157, filed on 12/5/02, (98) U.S. provisional patent application serial no. 60/448,526, attorney docket no. 25791.185, filed on 2/18/03, (99) U.S. provisional patent application serial no. 60/461,539, attorney docket no. 25791.186, filed on 4/9/03, (100) U.S. provisional patent application serial no. 60/462,750, attorney docket no. 25791.193, filed on 4/14/03, (101) U.S. provisional patent application serial no. 60/436,106, attorney docket no. 25791.200, filed on 12/23/02, (102) U.S. provisional patent application serial no. 60/442,942, attorney docket no. 25791.213, filed on 1/27/03, (103) U.S. provisional patent application serial no. 60/442,938, attorney docket no. 25791.225, filed on 1/27/03, (104) U.S. provisional patent application serial no. 60/418,687, attorney docket no. 25791.228, filed on 4/18/03, (105) U.S. provisional patent application serial no. 60/454,896, attorney docket no. 25791.236, filed on 3/14/03, (106) U.S. provisional patent application serial no. 60/450,504, attorney docket no. 25791.238, filed on 2/26/03, (107) U.S. provisional patent application serial no.

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[000336] Referring now to Figs. 21a and 21b, a system 2310 for radially expanding a tubular member is illustrated which includes a support member 2312 and an expansion device 2314. In one embodiment, the system 2310 may be used to radially expand and plastically deform a tubular member 2316 by displacing the expansion device 2314 in the longitudinal direction and/or by rotating the expansion device 2314 relative to the tubular member 2316. In an exemplary embodiment, as illustrated in Fig. 21a, expansion is carried out on the tubular member 2316 by displacing the expansion device 2314 through the tubular member 2316 in a direction 2317a. In an exemplary embodiment, as illustrated in Fig. 21b, expansion is carried out on the tubular member 2316 by displacing the expansion device 2314 through the tubular member 2316 in a direction 2317b, which is opposite the direction 2317a, illustrated in Fig. 21a. In an exemplary embodiment, the expansion device 2314 may be adjustable and/or adaptable in order to expand the tubular member 2316.

[000337] Referring now to Figs. 22a and 22b, an exemplary embodiment of an expansion device 2414 is illustrated which may be, for example, the expansion device 2314 illustrated in Figs. 21a and 21b. Expansion device 2414 may include one or more expansion device segments 2418 for engaging, and thereby radially expanding and plastically deforming, a tubular member such as, for example, the tubular member 2316 illustrated in Figs. 21a and 21b. In an exemplary embodiment, expansion device segment 2418 may include a segment of a conventional expansion cone and/or a conventional roller expansion element. As illustrated, expansion device segment 2418 is rotatably coupled to support structure 2420. In turn, support structure 2420 may be coupled to a support member 2421. A cam 2422 may be coupled to expansion device segment 2418 such that it is operable to engage the expansion device segment 2418. In an exemplary embodiment, the cam 2422 laterally supports expansion device segment 2418. A driving mechanism 2424 may be coupled to a motor 2425 and the cam 2422 in order to operate and rotate the cam 2422.

[000338] As illustrated in Figure 22a, expansion device segment 2418 may begin positioned in a first small diameter position $A_1$. As illustrated in Figure 22b, the driving mechanism 2424 may be activated by the motor 2425 in order actuate the cam 2422 and to pivot the expansion device segment 2418 about the support structure 2420 and position the expansion device segment 2418 in a second large diameter position $A_2$.

[000339] Referring now to Fig. 23a, a cross sectional view of an exemplary embodiment of the expansion device 2414 of Fig. 22a is illustrated showing the expansion device segment 2418 positioned in the first small diameter position $A_1$. The cam 2422 is rotatably coupled off center to the driving mechanism 2424. The cam 2422 is illustrated as having a circular shape, however, the cam 2422 may be of any suitable shape known in the art such as, for example, elliptical, triangular, or irregular.

[000340] As illustrated in Fig. 23a, with the cam 2422 and the expansion device segment 2418 in the first small diameter position $A_1$, a distance $B_1$ between driving mechanism 2424 and expansion device 2418 is minimized. However, as illustrated in Fig. 23b, the cam 2422 may be rotated by the driving mechanism 2424 and into to second

large diameter position $A_2$ such that a distance $B_2$ between driving mechanism 2424 and expansion device segment 2418 increases, causing an expansion device segment 2418 to expand in a direction 2426. In an exemplary embodiment, the expansion device 2414 may be adjustable and/or adaptable in order to expand a tubular member such as, for example, the tubular member 2316 illustrated in Figs. 21a and 21b.

[000341] Referring now to Fig. 24, an alternative embodiment of an expansion device 2500 is substantially similar in design and operation with the expansion device 2414, described above with reference to Figs. 22a, 22b, 23a, and 23b, with the provision of a controller 2534 operably coupled to the motor 2525. The controller 2534 may also be in communication with one or more sensors 2536. A user interface 2538 may also be provided which may be in operable communication with controller 2534.

[000342] In an exemplary embodiment, the controller 2534 includes analog, digital, electronic, and/or hydraulic control elements that may be positioned within or coupled to expansion device 2500. In an exemplary embodiment, the user interface 2538 may include a conventional keyboard input device and/or a conventional display device and/or a conventional communication channel for linking the user interface 2538 to the controller 2534.

[000343] In an exemplary embodiment, during the operation of expansion device 2500, the controller 2534 is programmed to adjust the rotation of the cam 2422 as a function of one or more operating conditions that are sensed by the sensors 2536. In an exemplary embodiment, the sensed operating conditions sensed by the sensors 2536 may include the reaction forces of a tubular member such as, for example, the tubular member 2316 illustrated in Fig. 21a, the operating pressure of fluidic materials within a system and/or the tubular member such as, for example, the system 2310 and/or the tubular member 2316 illustrated in Fig. 21a, the rotational speed of a system such as, for example, the system 2310 illustrated in Fig. 21a, the longitudinal speed of a system such as, for example, the system 2310 illustrated in Fig. 21a, and/or one or more user defined inputs to the controller 2534 provided via the user interface 2538.

[000344] In an exemplary embodiment, at least one of the sensors 2536 includes a conventional strain gauge that senses the reaction force of a tubular member such as, for example, the tubular member 2316 illustrated in Fig. 21a, during the radial expansion and plastic deformation of the tubular member by a system such as, for example, the system 2310 illustrated in Fig. 21a. In an exemplary embodiment, increases in the sensed reaction force causes the controller 2534 to change the rotation of the cam 2422, thereby increasing or decreasing the lateral expansion position of the expansion device segment 2418. In this manner, the forces applied to a tubular member such as, for example, the tubular member 2316 illustrated in Fig. 21a, may be increased or decreased for example, to provide increased or decreased radial expansion forces as a function of the sensed reaction forces.

[000345] In an exemplary embodiment, at least one of the sensors 2536 includes a conventional pressure sensor that senses the operating pressures of fluidic materials within a system and/or tubular member such as, for example, the system 2310 and the tubular member 2316 illustrated in Fig. 21a, during the radial expansion and plastic deformation of the tubular member by the system. In an exemplary embodiment, the value of the sensed operating pressure causes the controller 2534 to rotate the cam 2422 to increase or decrease the stiffness of corresponding expansion device segments 2418. In this manner, the forces applied to a tubular member such as, for example, the tubular member 2316 illustrated in Fig. 21a, may be increased or decreased for example, to provide increased or decreased radial expansion forces as a function of the sensed operating pressures.

[000346] In an exemplary embodiment, the controller 2534 is programmed to adaptively adjust the rotation of one or more cams 2422, which in turn adjusts the lateral position of respective expansion device segments 2418. In this manner, a system such as, for example, the system 2310 illustrated in Fig. 21a, can provide an adaptive

expansion system having user defined operational characteristics that may vary as a function of one or more sensed operating conditions. In an exemplary embodiment, the expansion device 2500 may be adjustable and/or adaptable in order to expand a tubular member such as, for example, the tubular member 2316 illustrated in Figs. 21a and 21b.

[000347] Referring to Figs. 21a, 24, and 25a, in an exemplary embodiment, the tubular member 2310 is positioned adjacent to and partially within a tubular member 2600. The system 2310 is then used to radially expand and plastically deform the tubular member 2316 into overlapping engagement with the tubular member 2600. In an exemplary embodiment, during the radial expansion and plastic deformation of tubular member 2316 into overlapping engagement with the tubular member 2600, the reaction forces of overlapping ends of the tubular members 2316 and 2600 are sensed by one or more of the sensors 2536 and, if the sensed reaction forces increase, the cam 2422 may be rotated to laterally adjust respective expansion device segment 2418 to thereby increase or decrease the radial expansion forces applied to the overlapping ends of the tubular members 2316 and 2600. In this manner, the system 2310 can controllably adjust the radial expansion forces applied to overlapping tubular members thereby enhancing the radial expansion process. In an exemplary embodiment, the location of the overlapped ends of the tubular members 2316 and 2600 may be input into the controller 2534 using the user interface 2538 to control the rotation of the cam 2422, and therefore the lateral position of respective expansion device segment 2418 in combination with, or in the alternative to, the sensing of the reaction forces described above.

[000348] Referring again to Fig. 25a, in an exemplary embodiment, a force is applied to the support member 2312 in the direction 2317a, which results in the expansion device 2314 being displaced in the direction 2317a. The movement of expansion device 2314 in the direction 2317a causes the end of tubular member 2316 to expand into engagement with the end of tubular member 2600.

[000349] Referring now to Figs. 24 and 25b, in an exemplary embodiment, the system 2310 is used to radially expand and plastically deform a tubular member assembly including a first tubular member section 2700a and a second tubular member section 2700b which are coupled to each other by a threaded connection 2702. In an exemplary embodiment, during the radial expansion and plastic deformation of the threaded connection 2702, the reaction forces of the threaded connection 2702 are sensed by one or more of the sensors 2536 and the rotation of the cam 2422, which may be associated with the one or more expansion device segments 2418 of expansion device 2314, is adjusted to thereby minimize damage to the integrity of the threaded connection 2702 during the radial expansion process. For example, the rotation of the cam 2422 may be adjusted to reduce the lateral position of the expansion device segment 2418 to minimize damage to the integrity of the threaded connection 2702 during the radial expansion process. In an alternative embodiment, the location of the threaded connection 2702 may be input into the controller 2534 using the user interface 2538 to control the initiation of the adjustment of the cam 2422 and the lateral position of respective expansion device segments 2418 in combination with, or in the alternative to, the sensing of the reaction forces described above.

[000350] Referring again to Fig. 25b, in an exemplary embodiment, a force is applied to the support member 2312 in the direction 2317a, which displaces the expansion device 2314 in the direction 2317a and through the tubular member sections 2700a and 2700b, expanding the tubular member sections 2700a and 2700b and the threaded connection 2702.

[000351] Referring to Figs. 24 and 25c, in an exemplary embodiment, the system 2310 is used to radially expand and elastically deform a subterranean formation 2800 during the radial expansion and plastic deformation of the tubular member 2316. In one embodiment, during the radial expansion and plastic deformation of the tubular

member 2316 against the subterranean formation 2800, the reaction forces of the subterranean formation 2800 are sensed by one or more of the sensors 2536, and the rotation of the cam 2422 and the lateral position of expansion device segment 2418 of expansion device 2314 are increased to thereby increase the radial expansion forces applied to the subterranean formation 2800. In this manner, the system 2310 can controllably adjust the radial expansion forces applied to the subterranean formation 2800 surrounding the tubular member 2316 during the radial expansion and plastic deformation of the tubular member 2316. In an alternative embodiment, the location of the subterranean formation 2800 may be input into the controller 2534 using the user interface 2538 to control the rotation of the cam 2422 in combination with, or in the alternative to, the sensing of the reaction forces described above.

[000352] Referring again to Fig. 25c, in an exemplary embodiment, a force is applied to the support member 2312 in the direction 2317a, which displaces the expansion device 2314 in the direction 2317a, through the tubular member 2316. The displacement of the expansion device 2314 in the direction 2317a causes the tubular member 2316 to expand into engagement with the subterranean formation 2800.

[000353] More generally, the expansion devices 2314 and 2500 illustrated in Figs. 24 and 25a illustrate that the operational characteristics of the expansion devices 2314 and 2500 may be determined as a function of empirical data regarding the tubular member 2316 which is determined during a radial expansion testing procedure. For example, if a certain rotation of the cam 2422 for one or more of expansion device segments 2418 provides enhanced operational performance of the tubular member 2316 before, during, or after a radial expansion and plastic deformation of the tubular member 2316, then the preferred rotation of the cam 2422, or the range and/or variation in the rotation of the cam 2422, may be programmed into the controller 2534 to thereby provide enhanced radial expansion and plastic deformation of the tubular member 2316 using the expansion devices 2314 and/or 2500.

[000354] Referring now to Fig. 26a, an alternative embodiment of an expansion device 2900 is substantially similar in design and operation to the expansion devices 2414 and 2500, described above with reference to Figs. 22a, 22b, and 24, with the provision of a expansion segment 2902 engaging the cam 2422 and pivotally coupled to a support structure 2904 which is mounted to a support member 2906 and positioned opposite the expansion segment 2418.

[000355] Referring now to Figs. 26a and 26b, the expansion device segments 2418 and 2902 begin in a first small diameter position $C_I$. The motor 2425 may then activate the driving mechanism 2424 in order to actuate the cam 2422 and move the expansion device segments 2418 and 2902 into a second large diameter position $C_L$. In an exemplary embodiment, expansion device segments 2418 and 2902 may include segments of a conventional expansion cone and/or conventional roller expansion elements. The cam 2422 may be movably coupled to expansion device segments 2418 and 2902. In an exemplary embodiment, the cam 2422 laterally supports the expansion device segments 2418 and 2902. The driving mechanism 2424 may be coupled to the cam 2422 in order to operate and rotate the cam 2422.

[000356] Referring now to Fig. 27a, in an exemplary embodiment, the cam 2422 is elliptically shaped and positioned adjacent the expansion device segments 2418 and 2902 and rotated such that the expansion device segments 2418 and 2902 are in the first small diameter position $C_I$. In an exemplary embodiment, the cam 2422 may be of any suitable shape known in the art such as, for example, triangular or irregular. In an exemplary embodiment, a distance 2908 between the center of the cam 2422 and the expansion device segments 2418 and 2902 is minimized when the expansion device segments 2418 and 2902 are in the first small diameter position $C_I$. In response to the cam 2422 being rotated about the driving mechanism 2424, the distance between the center of the

cam 2422 and the expansion device segments 2418 and 2902 increases to a maximum distance 2910 when the expansion device segments 2418 and 2902 are in the second large diameter position $C_2$, as illustrated in Fig. 27b, causing the expansion device segments 2418 and 2902 to expand in a lateral direction 2912. In an exemplary embodiment, the expansion device 2900 may be adjustable and/or adaptable in order to expand a tubular member such as, for example, the tubular members 2316, 2600, 2700a, and 2700b illustrated in Figs. 21a, 21b, 25a, 25b, and 25c.

[000357] Referring now to Figs. 28 and 28a, an alternative embodiment of an expansion device 3000 is substantially similar in design and operation to the expansion device 2900, described above with reference to Figs. 26a, 26b, 27a, and 27b, with the provision of a plurality of expansion device segments 3002a and 3002b interlaced with the expansion device segments 2418 and 2902. A secondary cam 3004 is coupled to the cam 2422 and the expansion device segments 3002a and 3002b engage the secondary cam 3004 while being pivotally coupled to a plurality of support structures 3006a and 3006b, respectively, which are mounted to a plurality of support members 3008a and 3008b, respectively. The expansion device segments 3002a and 3002b may include segment of a conventional expansion cone and/or a conventional roller expansion element. In an exemplary embodiment, cam 2422 laterally supports expansion device segments 2418 and 2902 and cam 3004 laterally supports expansion device segments 3002a and 3002b.

[000358] Referring again to Figs. 28 and 28a, in an exemplary embodiment, expansion device segments 2418, 2902, 3002a, and 3002b are all radially aligned about an axis of the driving mechanism 2424.

[000359] Referring now to Figs. 28, 28a, 29a, and 29b, in an exemplary embodiment, the expansion device segments 2418 are aligned as illustrated in Fig. 29a, and the expansion device segments 3002a and 3002b are positioned rotated 90° about an axis of the driving mechanism 2424 relative to expansion device segments 2902, as illustrated in Fig. 29b. The positioning illustrated in Figs. 29a and 29b allows the expansion device segments 2418 and 2902 to cover about one half of an inner circumference of a tubular member which may be, for example, the tubular members 2316, 2600, or 2700a and 2700b, described above with reference to Figs. 21a, 25a, and 25b, and allows the expansion device segments 3002a and 3002b to cover the remaining one half of the inner circumference of the tubular member.

[000360] Referring now to Figs. 29a and 29b, the cams 2424 and 3004 are in a first small diameter position $D_1$ in which a distance 3010a between the center of cam 2424 and the expansion devices 2418 and 2902 is minimized, and a distance 3010b between the center of cam 3004 and the expansion devices 3002a and 3002b is minimized. As illustrated, the long axis of cams 2424 and 3004 are orientated perpendicular to each other. The cams 2422 and 3004 may then be rotated to a second large diameter position $D_2$, illustrated in Figs. 29c and 29d, such that a distance 3012a between the center of cam 2422 and expansion device segments 2418 and 2902 substantially increases, causing expansion device segments 2418 and 2902 to laterally expand. Rotation of the cams 2424 and 3004 to a second large diameter position $D_2$ also results in a distance 3012b between the center of cam 3004 and the expansion device segments 3002a and 3002b substantially increasing, causing expansion device segments 3002a and 3002b to laterally expand. Cams 2424 and 3004 may be independently controlled, thereby allowing one set of expansion device segments to exert a greater lateral force than the other set of expansion devices, or control together with one driving mechanism. In an exemplary embodiment, the expansion device 300 may be adjustable and/or adaptable in order to expand a tubular member such as, for example, the tubular members 2316, 2600, 2700a, and 2700b illustrated in Figs. 21a, 21b, 25a, 25b, and 25c.

[000361] Referring now to Fig. 29e, in an exemplary embodiment, the cam 2422 and its corresponding expansion device segments 2418 and 2902 may be offset from and positioned above the cam 3004 and its corresponding expansion device segments 3002a and 3002b. As illustrated, the long axis of cams 2424 and 3004 are orientated perpendicular to each other. In an exemplary embodiment, the cams 2424 and 3004 may be independently controlled, thereby allowing one set of expansion device segments to exert a greater lateral force than the other set of expansion devices. In an exemplary embodiment, the cams 2424 and 3004 may be jointly controlled by driving mechanism 2424.

[000362] As illustrated, expansion device segment 2418 has an arc angle $E_1$ of approximately 90°, expansion device segment 3002b has an arc angle $E_2$ of approximately 90°, expansion device segment 2902 has an arc angle $E_3$ of approximately 90°, and expansion device segment 3002a has an arc angle $E_4$ of approximately 90°. As shown, arc angles $E_1$, $E_2$, $E_3$, and $E_4$ add up to about 360°, with no significant overlap.

[000363] In an alternative embodiment, each of arc angles $E_1$, $E_2$, $E_3$, and $E_4$ is about 120° to 150° such that portions of expansion device segments 2418 and 2902 circumferentially overlap with portions of expansion device segments 3002a and 3002b. However, there is no interference since expansion device segments 2418 and 2902 are vertically spaced or offset from segments 3002a and 3002b.

[000364] In an exemplary embodiment, expansion device segments 2418 and 2902 may be pushed and/or pulled through a tubular member which may be, for example, the tubular members 2316, 2600, or 2700a and 2700b, described above with reference to Figs. 21a, 25a, and 25b, in an expanded condition such that a section of cylindrical tubular member is expanded into an elliptical shape. Expansion device segments 3002a and 3002b may then be pushed and/or pulled through the same section of the tubular member, whereby expansion device segments 3002a and 3002b are offset or rotated about 90° from expansion device segments 2418 and 2902 in order to expand the section of the tubular member from an elliptical shape into a circular shape.

[000365] Referring now to Figs. 30a and 30c, an alternative embodiment of an expansion device 3100 is substantially similar in design and operation to the expansion device 2900, described above with reference to Figs. 26a and 26b, with the provision of a plurality of support structures 3102a and 3102b replacing the support structures 2420 and 2904 which allow the expansion device segments 2418 and 2902 to translate laterally as opposed to pivoting. The expansion device segments 2418 and 2902 are operable to engage and thereby radially expand and plastically deform a tubular member which may be, for example, the tubular members 2316, 2600, or 2700a and 2700b, described above with reference to Figs. 21a, 25a, and 25b. In an exemplary embodiment, expansion device segments 2418 and 2902 may include segments of a conventional expansion cone and/or a conventional roller expansion elements. The cam 2422 may be coupled to the expansion device segments 2418 and 2902 in a manner previously described. In an exemplary embodiment, the cam 2422 laterally supports the expansion device segments 2418 and 2902. The driving mechanism 2424 may be coupled to the cam 2422 in order to operate and rotate the cam 2424.

[000366] In operation, expansion device segments 2418 and 2902 begin proximate to the longitudinal sides of the cam 2424, positioning the expansion device 3100 is in a first small diameter position $F_1$, illustrated in Figs. 30a and 30c. In first small diameter position $F_1$, the distance between the center of driving mechanism 2424 and expansion device segments 2418 and 2902 is minimized. The cam 2422 may then be rotated through the driving mechanism 2424 by the motor 2425 in order to cause expansion device segments 2418 and 2902 to translate outward, positioning expansion device 3100 in a second large diameter position $F_2$, illustrated in Figs. 30b and 30d, which increases the distance between the center of the driving mechanism 2424 and expansion device segments

2418 and 2902 and causes the expansion device 3100 to expand in a lateral direction. Support structures 3102a and 3102b allow for a lateral translation while supporting expansion device segments 2418 and 2902 longitudinally. In an exemplary embodiment, the expansion device 3100 may be adjustable and/or adaptable in order to expand a tubular member such as, for example, the tubular members 2316, 2600, 2700a, and 2700b illustrated in Figs. 21a, 21b, 25a, 25b, and 25c.

[000367] Referring now to Fig. 31a, an alternative embodiment of an expansion device 3200 is substantially similar in design and operation to the expansion device 3100, described above with reference to Figs. 30a and 30b, with provision of a plurality of collets 3202a and 3202b coupled together by a mandrel 3204 which replaces the cam 2422. The collet 3202a includes a plurality of opposing wedged surfaces 3202aa and 3202ab and the collet 3202b includes a plurality of opposing wedged surface 3202ba and 3202bb. Expansion device segment 2418 is provided with a plurality of opposing surfaces 3206a and 3206b and expansion device segment 2902 is provided with a plurality of opposing surfaces 3208a and 3208b. A motor 3210 is provided and coupled to the collets 3202a and 3202b and the mandrel 3204 by a driving mechanism 3212 and is positioned opposite the motor 2425 and the driving mechanism 2424, which are also coupled to the collets 3202a and 3202b and the mandrel 3204. The motors 2425 and 3210 are operable to move the collets 3202a and 3202b towards each other on the mandrel 3204. Expansion device 3200 is operable to engage and thereby radially expand and plastically deform a tubular member which may be, for example, the tubular members 2316, 2600, or 2700a and 2700b, described above with reference to Figs. 21a, 25a, and 25b. In an exemplary embodiment, the expansion device segments 2418 and 2902 may include segments of a conventional expansion cone and/or conventional roller expansion elements. As illustrated, expansion device segments 2418 and 2902 are coupled to the support structures 3102a and 3102b, respectively, which allow lateral translation of the expansion device segments 2418 and 2902. The two collets 3202a and 3202b are positioned facing each other along the mandrel 3204. In an exemplary embodiment, the collets 3202a and 3202b are generally cone or wedged shaped and are coupled to expansion device segments 2418 and 2902 such that, as collets 3202a and 3202b move relative to each other longitudinally, the expansion device segments 2418 and 2902 move laterally relative to each other. For example, as the collet 3202a moves along the mandrel 3204 and towards the collet 3202b, wedged surfaces 3202aa and 3202ab of collet 3202a engage surfaces 3606a and 3808a, respectively, on engagement device segment 2418, and wedged surfaces 3202ba and 3202bb of collet 3202b engage surfaces 3606b and 3808b, respectively, on engagement device segment 2902, driving the expansion device segments 2418 and 2902 apart in a lateral direction as illustrated in Fig. 31b.

[000368] In operation, the collets 3202a and 3202b begin at a maximum longitudinal distance from each other, as illustrated in Fig. 31a, with expansion device segments 2418 and 2902 positioned relatively close to each other such that expansion device 3200 is in a first small diameter position $G_1$. The motors 2425 and 3210 may then be actuated to move the collets 3202a and 3202b to a minimum longitudinal distance from each other, as illustrated in Fig. 31b, such that expansion device segments 2418 and 2902 are in a second large diameter position $G_2$. The support structures 3102a and 3102b allow for a lateral translation of the expansion device segments 2418 and 2902 while supporting the expansion device segments 2418 and 2902 longitudinally. In an exemplary embodiment, the expansion device 3200 may be adjustable and/or adaptable in order to expand a tubular member such as, for example, the tubular members 2316, 2600, 2700a, and 2700b illustrated in Figs. 21a, 21b, 25a, 25b, and 25c.

[000369] Referring now to Fig. 32, an expansion device 3300 is illustrated. Expansion device 3300 includes a top expansion device 3302a and bottom expansion device 3302b which are coupled together by an intervening support member 3304 and positioned within a tubular member 3305. The top expansion device 3302a is coupled to

a support member 3306. A bottom cup seal 3308 and a top cup seal 3310 are coupled to the support member 3306 and positioned spaced apart and above the top expansion member 3302a. In operation, a relatively large pressure may be applied to an annular region 3312 within the tubular member 3305 and a relatively small pressure may be applied to an annular region 3314 within the tubular member 3305, which results in a pressure differential that applies a force to the bottom cup seal 3308 and the top cup seal 3310 in a direction 3316. This force is translated from the bottom cup seal 3308 and the top cup seal 3310 to the support member 3306, which pulls top expansion device 3302a, the intervening support member 3304, and bottom expansion device 3302b in the direction 3316 and may result in the expansion of the tubular member 3305 when the top expansion device 3302a and the bottom expansion device 3302b are expanded such as, for example, in a manner described above with reference to the expansion devices 2314, 2414, 2500, 2900, 3000, 3100, and 3200. In an exemplary embodiment, the expansion device 3300 may be adjustable and/or adaptable in order to expand a tubular member such as, for example, the tubular members 2316, 2600, 2700a, and 2700b illustrated in Figs. 21a, 21b, 25a, 25b, and 25c.

[000370] Referring now to Fig. 33a, an exemplary embodiment of an expansion device 3400 is illustrated. Expansion device 3400 includes an expansion device 3402 with an angled edge 3402a and which is coupled to support member 3404 and positioned within a tubular member 3406 which may be, for example, the tubular members 2316, 2600, or 2700a and 2700b, described above with reference to Figs. 21a, 25a, and 25b. The tubular member 3406 is located in a wellbore 3408 which includes a wellbore casing 3310 which engages the walls of the wellbore 3408. The tubular member 3406 also includes an expansion sleeve 3412 positioned within the tubular member 3406 and a seal 3414 positioned adjacent an end 3416 of the tubular member 3406 and on an outer surface of the tubular member 3406. In operation, as illustrated in Figs. 33a and 33b, the support member 3404 pulls the expansion device 3402 in a direction 3416, resulting in the angled edge 3402a of expansion device 3402 engaging the expansion sleeve 3412. Upon engagement, the expansion sleeve 3412 plastically deforms around the angled edge 3402a of the expansion device 3402 due to the inside diameter of expansion sleeve 3412 being smaller than the outside diameter of expansion device 3402, and the expansion sleeve 3412 couples to the angled edge 3402a of the expansion device 3402. Engagement of the expansion sleeve 3412 and the expansion device 3402 provides the expansion device 3402 with a large enough diameter to expand the tubular member 3406, as illustrated in Fig. 33b.

[000371] As the expansion device 3402 begins its engagement with expansion sleeve 3412, the expansion sleeve 3412 may be attached to tubular member 3406. After the engagement, the expansion sleeve 3412 detaches from the tubular member 3406 and begins to travel through the tubular member 3406 with the expansion device 3402. In an exemplary embodiment, expansion sleeve 3412 may be attached to tubular member 3406 with shear pins.

[000372] In an exemplary embodiment, the expansion device 3402 has a fixed diameter, such that the expansion device 3402 may be placed in the wellbore 3408 prior to placing the expansion sleeve 3412 in the wellbore 3408 such as, for example, when the expansion device 3402 is used to expand the tubular member 3416 when traveling in direction 3416. In an exemplary embodiment, the expansion device 3402 has a diameter that may vary from a small diameter configuration to a large diameter configuration, such that the expansion sleeve 3412 may be placed in the wellbore 3408 before the expansion device 3402 is fed through the tubular member 3406 and the expansion sleeve 3412 in small diameter configuration. The expansion device 3402 may then be expanded from the small diameter configuration to the large diameter configuration, where the large diameter configuration is larger than the inside diameter of the expansion sleeve 3412. In an exemplary embodiment, the expansion device 3400 may be adjustable

and/or adaptable in order to expand a tubular member such as, for example, the tubular members 2316, 2600, 2700a, 2700b, and 3406 illustrated in Figs. 21a, 21b, 25a, 25b, 25c, 33a, and 33b.

[000373] Referring now to Figs. 34a, 34b, 34c, and 34d, an alternative embodiment of an expansion device 3500 is substantially similar in design and operation to the expansion device 2414, described above with reference to Figs. 22a and 22b, with provision of an expansion device roller 3502 which is rotatably coupled to an axle 3504 which extends from either end of the roller 3502 and which couples the roller 3502 to the structure support 2420. In an exemplary embodiment, expansion device 3500 may include one or more expansion device rollers 3502 for engaging, and thereby radially expanding and plastically deforming a tubular member which may be, for example, the tubular members 2316, 2600, or 2700a and 2700b, described above with reference to Figs. 21a, 25a, and 25b. In an exemplary embodiment, expansion device roller 3502 may include a roller of a conventional roller expansion element. The cam 2422 is movably coupled to an end of the axle 3504. In an exemplary embodiment, the cam 2422 laterally supports the axle 3504. The driving mechanism 2424 is coupled to the cam 2422 and operable to operate and rotate the cam 2422. The cam 2422 may be of any suitable shape, including circular, elliptical, triangular, or irregular.

[000374] Referring now to Figs. 34a, 34b, 34c, and 34d, in operation, the expansion device 3500 begins in a first small diameter position $H_1$, as illustrated in Figs. 34a and 34c. The cam 2422 may then be rotated through the driving mechanism 2424 by the motor 2425, whereby the engagement of the cam 2422 with the axle 3504 places the expansion device 3500 in a second large diameter position $H_2$, as illustrated in Figs. 34b and 34d. Rotating the cam 2422 causes the expansion device roller 3502 to expand laterally. Although the expansion device roller 3502 is shown with a cylindrical shape, the expansion device roller 3502 may be of any suitable shape known in the art such as, for example barrel-shaped, conical, and/or frustroconical. In an exemplary embodiment, there may also be provided suitable bearings and/or lubricants and/or seals between expansion device roller 3502 and the axle 3504. In an exemplary embodiment, the expansion device 3500 may be adjustable and/or adaptable in order to expand a tubular member such as, for example, the tubular members 2316, 2600, 2700a, 2700b, and 3406 illustrated in Figs. 21a, 21b, 25a, 25b, 25c, 33a, and 33b.

[000375] Referring now to Figs. 35a and 35c, an alternative embodiment of an expansion device 3600 is substantially similar in design and operation to the expansion device 3100, described above with reference to Figs. 30a and 30b, with the provision of a plurality of expansion member rollers 3602a and 3602b replacing the expansion member sections 2418 and 2902. Expansion member roller 3602a is rotatably coupled to an axel 3604 which extends from either end of the expansion member roller 3602a and which is coupled to the support structures 3102a and 3102b, the cam 2422, and a cam 3606 which is coupled to the driving mechanism 2424. Expansion member roller 3602b is rotatably coupled to an axel 3608 which extends from either end of the expansion member roller 3602b and which is coupled to the support structures 3102a and 3102b, the cam 2422, and the cam 3606. The expansion device 3600 may include one or more expansion device rollers 3602a and 3602b for engaging, and thereby radially expanding and plastically deforming, a tubular member. In an exemplary embodiment, expansion device rollers 3602a and 3602b may include conventional roller expansion elements. In an exemplary embodiment, the cams 3606 and 2422 laterally support the axles 3604 and 3608. The driving mechanism 2424 may be coupled to the cams 3606 and 2422 and operable to operate and rotate the cams 3606 and 2422.

[000376] Referring now to Figs. 35a, 35b, 35c, and 35d, in operation, the expansion device rollers 3602a and 3602b begin proximate to the longitudinal sides of cams 3606 and 2422 such that the expansion device 3600 is in a first small diameter position $I_1$, illustrated in Figs. 35a and 35c, in which the distance between the center of the

driving mechanism 2424 and expansion device rollers 3602a and 3602b is minimized. The cams 3606 and 2422 may then be rotated such that their engagement with the axels 3604 and 3608 causes the expansion device 3600 to be positioned in a second large diameter position $I_2$, illustrated in Figs. 35b and 35d, in which the distance between the center of the driving mechanism 2424 and the expansion device rollers 3602a and 3602b substantially increases, causing expansion device rollers 3602a and 3602b to expand in a lateral direction. The support structures 3102a and 3102b allow for a lateral translation while supporting axles 3602a and 3602b and expansion device rollers 3602a and 3602b longitudinally.

[000377] In an exemplary embodiment, there may also be provided suitable bearings and/or lubricants and/or seals between the expansion device rollers 3602a and 3602b and the axles 3602a and 3602b. In an exemplary embodiment, the expansion device 3600 may be adjustable and/or adaptable in order to expand a tubular member such as, for example, the tubular members 2316, 2600, 2700a, 2700b, and 3406 illustrated in Figs. 21a, 21b, 25a, 25b, 25c, 33a, and 33b.

[000378] Referring now to Fig. 36a, an alternative embodiment of an expansion device 3700 is substantially similar in design and operation to the expansion device 3600 described above with reference to Figs. 35a and 35b with the provision of a plurality of piston actuation structures 3702a and 3702b replacing the support structures 3102a and 3102b and the cams 3606 and 2422. The piston actuation structures 3702a and 3702b are coupled to and actuated by the driving mechanism 2424, with piston actuation structure 3702a including a rod 3702aa coupled to axle 3604 and a rod 3702ab coupled to axle 3608, and piston actuation structure 3702b including a rod 3702ba coupled to axle 3604 and a rod 3702bb coupled to axle 3608. The expansion device 3700 may include one or more expansion device rollers 3602a and 3602b for engaging, and thereby radially expanding and plastically deforming, a tubular member which may be, for example, the tubular members 2316, 2600, or 2700a and 2700b, described above with reference to Figs. 21a, 25a, and 25b. In an exemplary embodiment, expansion device rollers 3602a and 3602b may include conventional roller expansion elements. Piston actuation structures 3702a and 3702b may include conventional piston-type actuators known in the art.

[000379] Referring now to Figs. 36a and 36b, in operation, rods 3702aa and 3702ab on piston actuation structure 3702a and rods 3702ba and 3702bb on piston actuation structure 3702b are retracted, resulting in the expansion device rollers 3602a and 3602b being positioned adjacent the piston actuation structures 3702a and 3702ba and the expansion device 3700 being positioned in a first small diameter position $J_1$, as illustrated in Fig. 36a, in which the distance between the center of driving mechanism 2424 and the expansion device rollers 3602a and 3602b is minimized. Piston actuations structures 3702a and 3702b may then be actuated which translates the axles 3604 and 3608 outward such that the expansion device rollers 3602a and 3602b are extended away from the driving mechanism 2424 and the expansion device 3700 is positioned in a second large diameter position $J_2$, as illustrated in Fig. 36b, in which the distance between the center of driving mechanism 2424 and expansion device rollers 3602a and 3602b substantially increases. Piston actuations structures 3702a and 3702b allow for a lateral translation of the expansion device rollers 3602a and 3602b while supporting the axles 3604 and 3608 and the expansion device rollers 3602a and 3602b longitudinally.

[000380] In an exemplary embodiment, the piston actuations structures 3702a and 3702b may be operated by using a pressurized gas or fluid. The pressure of the pressurized gas or fluid may be adjusted to exert a specific force on expansion device rollers 3602a and 3602b. The predetermined pressure and force can be constant throughout an expansion process, or variable depending on what section of the tubular member is being expanded.

For example, a larger pressure and force may be desired in the middle of the tubular member, but a smaller pressure and force may be desired at an end of the tubular member such as, for example, adjacent a threaded connections.

[000381] In another embodiment, there may also be provided suitable bearings and/or lubricants and/or seals between expansion device rollers 3602a and 3602b and axles 3604 and 3608. In an exemplary embodiment, the expansion device 3600 may be adjustable and/or adaptable in order to expand a tubular member such as, for example, the tubular members 2316, 2600, 2700a, 2700b, and 3406 illustrated in Figs. 21a, 21b, 25a, 25b, 25c, 33a, and 33b.

[000382] Referring now to Figs. 37a and 37b, an exemplary embodiment of an expansion system 3800 is illustrated. Expansion system 3800 includes an expansion device 3802 which is coupled to a support member 3803. Expansion device 3802 includes a flexible metal skin 3804, a plurality of inserts 3806, and a bladder 3808 which is coupled to the support member 3803 such that a pressurized fluid or gas may be fed through the support member 3803 and into the bladder 3708 in order to expand the expansion device 3802. When the bladder 3808 is not filled with pressurized fluid or gas, the expansion device 3802 has a retracted configuration $K_1$, as illustrated in Figs. 37a and 37b.

[000383] Referring now to Figs. 38a and 38b, in operation, the bladder 3802 may be filled with pressurized fluid or gas which may be fed through the support member 3803 in order to place the expansion device 3802 into an expanded configuration $K_2$, as illustrated in Figs. 38a and 38b. The expansion system 3800 may then be displaced through a tubular member which may be, for example, the tubular members 2316, 2600, or 2700a and 2700b, described above with reference to Figs. 21a, 25a, and 25b, in order to expand and plastically deform the tubular member. The inserts 3806 may provide a durable point of contact for the expansion device 3802 as it is used to expand and plastically deform the tubular member.

[000384] The Inserts 3806 may be made of a hard material, for example a metal carbide, a diamond, a tool steel, or other suitable materials used for tool inserts. In an exemplary embodiment, the expansion device 3802 may be adjustable and/or adaptable in order to expand a tubular member such as, for example, the tubular members 2316, 2600, 2700a, 2700b, and 3406 illustrated in Figs. 21a, 21b, 25a, 25b, 25c, 33a, and 33b.

[000385] Referring now to Figs. 39a, 39b, and 39c, an exemplary embodiment of an expansion device 3900 is illustrated. Expansion device 3900 includes an expandable member 3902 and a support mandrel 3903. Expandable member 3902 includes a first large section 3904, a second large section 3906, a third large section 3908, a first small section 3910, a second small section 3912, and a third small section 3914. Although illustrated with three large sections and three small sections, in an exemplary embodiment the number of small sections can vary from about 2 to about 10, and the number of large sections can vary from about 2 to about 10. In an exemplary embodiment, the number of small sections can vary from about 3 to about 5, and the number of large sections can vary from about 3 to about 5.

[000386] In operation, the expansion member 3902 may be placed within a retaining sleeve 3918 to hold the expansion member 3902 in a collapsed configuration $L_1$. To collapse expansion member 3902, support mandrel 3903 is removed from within expansion device 3902. Each of first large section 3904, second large section 3906, third large section 3908, first small section 3910, second small section 3912, and third small section 3914 may be cantilevered or pivotally mounted to a section retainer and, after support mandrel 3916 is removed, each of first large section 3904, second large section 3906, third large section 3908, first small section 3910, second small section 3912, and third small section 3914 will collapse into the collapsed configuration $L_1$ on their own, allowing expansion member 3902 to be pushed and/or pulled through a small opening.

[000387] The support mandrel 3903 may then be centrally positioned within the expansion member 3902 to support first large section 3904, second large section 3906, third large section 3908, first small section 3910, second small section 3912, and third small section 3914. The expansion device 3900 may then be displaced through a tubular member which may be, for example, the tubular members 2316, 2600, or 2700a and 2700b, described above with reference to Figs. 21a, 25a, and 25b, in order to radially expand and plastically deform the tubular member.

[000388] To expand expansion member 3902, retaining sleeve 3918 is removed, and support mandrel 3903 is forced within first small section 3910, second small section 3912, and third small section 3914, which small sections 3910, 3912, and 3914 then engage first large section 3904, second large section 3906, third large section 3908, in order to place the expansion device 3900 in an expanded configuration $L_2$, as illustrated in Figs. 39b and 39b. In an exemplary embodiment, the expansion device 3900 may be adjustable and/or adaptable in order to expand a tubular member such as, for example, the tubular members 2316, 2600, 2700a, 2700b, and 3406 illustrated in Figs. 21a, 21b, 25a, 25b, 25c, 33a, and 33b.

[000389] Referring now to Figs. 40a, 40b, and 40c, an exemplary embodiment of an expansion member 4000 is illustrated. Expansion member 4000 includes an expansion device 4002 which may be used to radially expand and plastically deform a tubular member which may be, for example, the tubular members 2316, 2600, or 2700a and 2700b, described above with reference to Figs. 21a, 25a, and 25b. Expansion device 4002 includes a cam 4004 and a plurality of expansion segments 4006 positioned about the perimeter of the cam 4004. Each expansion segments 4006 includes a leading edge 4008 and trailing edge 4010. At each leading edge 4008 is groove 4012, and at each trailing edge 4010 is key 4014. Although the expansion device 4002 is shown with six expansion segments, the number of expansion segments can be between about 3 to about 30 and one embodiment, and between about 5 and about 10 in another embodiment, with a suitably shaped cam in each embodiment.

[000390] Referring now to Fig. 40c, the key 4014 and the groove 4012 are operable to slidingly engage. Each key 4014 on trailing edge 4010 of each expansion segment 4006 is adapted to slide within each groove 4012 on leading edge 4008 of adjacent expansion segment 4006. Each groove 4012 has stops at each end to prevent key 4014 from leaving groove 4012 and disengaging adjacent expansion segments 4006.

[000391] Referring now to Fig. 40a, in operation, the expansion device 4002 begins in a collapsed configuration $M_1$, as illustrated in Fig. 40a. Each expansion segment 4006 may overlap with adjacent expansion segments 4006. Each expansion segment 4006 is operable to collapse into the collapsed configuration $M_1$, as illustrated in Fig. 40a, on their own, when expansion device 4002 is pushed and/or pulled through a small opening and/or when a retaining sleeve or similar device known in the art is forced over expansion device 4002.

[000392] Referring now to Fig. 40b, the cam 4004 may be rotated, which forces expansion segments 4006 from their overlapping configuration into an expanded configuration $M_2$, as illustrated in Fig. 40b. In an exemplary embodiment, the expansion device 4002 may be adjustable and/or adaptable in order to expand a tubular member such as, for example, the tubular members 2316, 2600, 2700a, 2700b, and 3406 illustrated in Figs. 21a, 21b, 25a, 25b, 25c, 33a, and 33b.

[000393] Referring now to Fig. 41a, an expansion system 4100 is illustrated. Expansion system 4100 includes an expansion device 4102 having an outer expansion surface 4102a and including a laser cladded coating 4104 on the outer expansion surface 4102a which may be applied to the expansion device 4102 using methods for laser cladding known in the art. The laser cladded coating 4104 includes a wear resistant material and is of a thickness 4104a which are sufficient to impart a strength, toughness, and bond strength to the expansion device 4102 and a hardness in order to expand a tubular member which may be, for example, the tubular members 2316, 2600, or

2700a and 2700b, described above with reference to Figs. 21a, 25a, and 25b, by displacing the expansion system 4100 though the tubular member at a controlled rate. The material for the laser cladded coating 4104 and the expansion device 4102, the angle of the outer expansion surface 4102a, and the dimensions and geometry of the expansion device 4102 may be selected to minimize friction and tendency to gall. The expansion device 4102 may include a variety of materials known in the art which are of sufficient strength and ductility to support the laser cladded coating 4104 during operation such as, for example, low alloy steels. In an exemplary embodiment, as illustrated in Fig. 41b, the laser cladded coating 4104 includes a plurality of sections 4104b having greater thickness than the rest of the laser cladded coating 4104 in areas of the expansion system 4100 likely to experience higher wear.

[000394] In an exemplary embodiment, the thickness 4104a ranges between 0.020 and 0.100 inches. In an exemplary embodiment, the laser cladded coating 4104 includes tungsten carbide in a cobalt matrix which is applied to the expansion device 4102 using High Velocity Oxy-Fuel (HVOF). In an exemplary embodiment, the laser cladded coating 4104 may be applied to the expansion device 4102 by applying a finely divided and graded conglomerate of tungsten carbide and finely divided metal such as, for example, nickel or cobalt, with the use of a laser. The conglomerate passes through the path of the laser, which is directed at the outer expansion surface 4102a, and produces a fully metallurgical bond due to the outer expansion surface 4102a melting along with the finely divided metal. The process produces a cladding which has a relatively higher bond strength than conventional powder metallurgy processes such as, for example, flame spray, compaction, D-gun, etc.

[000395] In operation, the expansion system 4100 may be displaced through a tubular member which may be, for example, the tubular members 2316, 2600, or 2700a and 2700b, described above with reference to Figs. 21a, 25a, and 25b, in order to radially expand and plastically deform the tubular member. The laser cladded coating 4104 prevents galling of the expansion system 4100 during operation.

[000396] Referring now to Fig. 42a, an alternative embodiment of an expansion system 4200 is substantially identical in design and operation to the expansion system 4100, described above with reference to Fig. 41a, with the provision of diamond coating 4202 on the surface of the laser cladded coating 4104. The diamond coating 4202 and laser cladded coating 4104 include provide a wear resistance and are of a thickness which is sufficient to impart a strength, toughness, and bond strength to the expansion device 4102 and a hardness in order to expand a tubular member which may be, for example, the tubular members 2316, 2600, or 2700a and 2700b, described above with reference to Figs. 21a, 25a, and 25b, by displacing the expansion system 4200 though the tubular member at a controlled rate. The addition of the diamond coating 4202 decreases the friction coefficient between the expansion system 4200 and the inside surface of a tubular member to be expanded while increasing the resistance of the expansion system 4200 to wear and galling. In an exemplary embodiment, the diamond coating 4202 has a thickness on the order of microns as compared to the thickness 4104a of the laser cladded coating 4104, which may be between 0.020 and 0.100 inches. The diamond coating 4202 may be added to the expansion system 4102 using conventional methods known in the art. In an exemplary embodiment, the expansion device 3400 may be adjustable and/or adaptable in order to expand a tubular member such as, for example, the tubular members 2316, 2600, 2700a, 2700b, and 3406 illustrated in Figs. 21a, 21b, 25a, 25b, 25c, 33a, and 33b.

[000397] In other alternative embodiments, one or more of the embodiments of the present disclosure are implemented using the methods and/or apparatus disclosed in one or more of the following: (1) U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98,

(2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, which claims priority from provisional application 60/121,702, filed on 2/25/99, (3) U.S. Patent Number 6,823,937, which was filed as U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, which claims priority from provisional application 60/119,611, filed on 2/11/99, (4) U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (5) U.S. patent application serial no. 10/169,434, attorney docket no. 25791.10.04, filed on 7/1/02, which claims priority from provisional application 60/183,546, filed on 2/18/00, (6) U.S. patent no. 6,640,903 which was filed as U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (7) U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (8) U.S. patent number 6,575,240, which was filed as patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, which claims priority from provisional application 60/121,907, filed on 2/26/99, (9) U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (10) U.S. patent application serial no. 09/981,916, attorney docket no. 25791.18, filed on 10/18/01 as a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (11) U.S. patent number 6,604,763, which was filed as application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, which claims priority from provisional application 60/131,106, filed on 4/26/99, (12) U.S. patent application serial no. 10/030,593, attorney docket no. 25791.25.08, filed on 1/8/02, which claims priority from provisional application 60/146,203, filed on 7/29/99, (13) U.S. provisional patent application serial no. 60/143,039, attorney docket no. 25791.26, filed on 7/9/99, (14) U.S. patent application serial no. 10/111,982, attorney docket no. 25791.27.08, filed on 4/30/02, which claims priority from provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (15) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (16) U.S. provisional patent application serial no. 60/438,828, attorney docket no. 25791.31, filed on 1/9/03, (17) U.S. patent number 6,564,875, which was filed as application serial no. 09/679,907, attorney docket no. 25791.34.02, on 10/5/00, which claims priority from provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (18) U.S. patent application serial no. 10/089,419, filed on 3/27/02, attorney docket no. 25791.36.03, which claims priority from provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (19) U.S. patent application serial no. 09/679,906, filed on 10/5/00, attorney docket no. 25791.37.02, which claims priority from provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (20) U.S. patent application serial no. 10/303,992, filed on 11/22/02, attorney docket no. 25791.38.07, which claims priority from provisional patent application serial no. 60/212,359, attorney docket no. 25791.38, filed on 6/19/2000, (21) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (22) U.S. provisional patent application serial no. 60/455,051, attorney docket no. 25791.40, filed on 3/14/03, (23) PCT application US02/2477, filed on 6/26/02, attorney docket no. 25791.44.02, which claims priority from U.S. provisional patent application serial no. 60/303,711, attorney docket no. 25791.44, filed on 7/6/01, (24) U.S. patent application serial no. 10/311,412, filed on 12/12/02, attorney docket no. 25791.45.07, which claims priority from provisional patent application serial no.

60/221,443, attorney docket no. 25791.45, filed on 7/28/2000, (25) U.S. patent application serial no. 10/, filed on 12/18/02, attorney docket no. 25791.46.07, which claims priority from provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (26) U.S. patent application serial no. 10/322,947, filed on 1/22/03, attorney docket no. 25791.47.03, which claims priority from provisional patent application serial no. 60/233,638, attorney docket no. 25791.47, filed on 9/18/2000, (27) U.S. patent application serial no. 10/406,648, filed on 3/31/03, attorney docket no. 25791.48.06, which claims priority from provisional patent application serial no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, (28) PCT application US02/04353, filed on 2/14/02, attorney docket no. 25791.50.02, which claims priority from U.S. provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on 2/20/2001, (29) U.S. patent application serial no. 10/465,835, filed on 6/13/03, attorney docket no. 25791.51.06, which claims priority from provisional patent application serial no. 60/262,434, attorney docket no. 25791.51, filed on 1/17/2001, (30) U.S. patent application serial no. 10/465,831, filed on 6/13/03, attorney docket no. 25791.52.06, which claims priority from U.S. provisional patent application serial no. 60/259,486, attorney docket no. 25791.52, filed on 1/3/2001, (31) U.S. provisional patent application serial no. 60/452,303, filed on 3/5/03, attorney docket no. 25791.53, (32) U.S. patent number 6,470,966, which was filed as patent application serial number 09/850,093, filed on 5/7/01, attorney docket no. 25791.55, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (33) U.S. patent number 6,561,227, which was filed as patent application serial number 09/852,026 , filed on 5/9/01, attorney docket no. 25791.56, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (34) U.S. patent application serial number 09/852,027, filed on 5/9/01, attorney docket no. 25791.57, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (35) PCT Application US02/25608, attorney docket no. 25791.58.02, filed on 8/13/02, which claims priority from provisional application 60/318,021, filed on 9/7/01, attorney docket no. 25791.58, (36) PCT Application US02/24399, attorney docket no. 25791.59.02, filed on 8/1/02, which claims priority from U.S. provisional patent application serial no. 60/313,453, attorney docket no. 25791.59, filed on 8/20/2001, (37) PCT Application US02/29856, attorney docket no. 25791.60.02, filed on 9/19/02, which claims priority from U.S. provisional patent application serial no. 60/326,886, attorney docket no. 25791.60, filed on 10/3/2001, (38) PCT Application US02/20256, attorney docket no. 25791.61.02, filed on 6/26/02, which claims priority from U.S. provisional patent application serial no. 60/303,740, attorney docket no. 25791.61, filed on 7/6/2001, (39) U.S. patent application serial no. 09/962,469, filed on 9/25/01, attorney docket no. 25791.62, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99, (40) U.S. patent application serial no. 09/962,470, filed on 9/25/01, attorney docket no. 25791.63, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99, (41) U.S. patent application serial no. 09/962,471, filed on 9/25/01, attorney docket no. 25791.64, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from

provisional application 60/124,042, filed on 3/11/99, (42) U.S. patent application serial no. 09/962,467, filed on 9/25/01, attorney docket no. 25791.65, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99, (43) U.S. patent application serial no. 09/962,468, filed on 9/25/01, attorney docket no. 25791.66, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99, (44) PCT application US 02/25727, filed on 8/14/02, attorney docket no. 25791.67.03, which claims priority from U.S. provisional patent application serial no. 60/317,985, attorney docket no. 25791.67, filed on 9/6/2001, and U.S. provisional patent application serial no. 60/318,386, attorney docket no. 25791.67.02, filed on 9/10/2001, (45) PCT application US 02/39425, filed on 12/10/02, attorney docket no. 25791.68.02, which claims priority from U.S. provisional patent application serial no. 60/343,674 , attorney docket no. 25791.68, filed on 12/27/2001, (46) U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, (now U.S. Patent 6,634,431 which issued 10/21/2003), which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (47) U.S. utility patent application serial no. 10/516,467, attorney docket no. 25791.70, filed on 12/10/01, which is a continuation application of U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, (now U.S. Patent 6,634,431 which issued 10/21/2003), which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (48) PCT application US 03/00609, filed on 1/9/03, attorney docket no. 25791.71.02, which claims priority from U.S. provisional patent application serial no. 60/357,372 , attorney docket no. 25791.71, filed on 2/15/02, (49) U.S. patent application serial no. 10/074,703, attorney docket no. 25791.74, filed on 2/12/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (50) U.S. patent application serial no. 10/074,244, attorney docket no. 25791.75, filed on 2/12/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (51) U.S. patent application serial no. 10/076,660, attorney docket no. 25791.76, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (52) U.S. patent application serial no. 10/076,661, attorney docket no. 25791.77, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (53) U.S. patent application serial no. 10/076,659, attorney docket no. 25791.78, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (54) U.S. patent application serial no. 10/078,928, attorney docket no. 25791.79, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on

2/26/99, (55) U.S. patent application serial no. 10/078,922, attorney docket no. 25791.80, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (56) U.S. patent application serial no. 10/078,921, attorney docket no. 25791.81, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (57) U.S. patent application serial no. 10/261,928, attorney docket no. 25791.82, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (58) U.S. patent application serial no. 10/079,276, attorney docket no. 25791.83, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (59) U.S. patent application serial no. 10/262,009, attorney docket no. 25791.84, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (60) U.S. patent application serial no. 10/092,481, attorney docket no. 25791.85, filed on 3/7/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (61) U.S. patent application serial no. 10/261,926, attorney docket no. 25791.86, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (62) PCT application US 02/36157, filed on 11/12/02, attorney docket no. 25791.87.02, which claims priority from U.S. provisional patent application serial no. 60/338,996, attorney docket no. 25791.87, filed on 11/12/01, (63) PCT application US 02/36267, filed on 11/12/02, attorney docket no. 25791.88.02, which claims priority from U.S. provisional patent application serial no. 60/339,013, attorney docket no. 25791.88, filed on 11/12/01, (64) PCT application US 03/11765, filed on 4/16/03, attorney docket no. 25791.89.02, which claims priority from U.S. provisional patent application serial no. 60/383,917, attorney docket no. 25791.89, filed on 5/29/02, (65) PCT application US 03/15020, filed on 5/12/03, attorney docket no. 25791.90.02, which claims priority from U.S. provisional patent application serial no. 60/391,703, attorney docket no. 25791.90, filed on 6/26/02, (66) PCT application US 02/39418, filed on 12/10/02, attorney docket no. 25791.92.02, which claims priority from U.S. provisional patent application serial no. 60/346,309, attorney docket no. 25791.92, filed on 1/7/02, (67) PCT application US 03/06544, filed on 3/4/03, attorney docket no. 25791.93.02, which claims priority from U.S. provisional patent application serial no. 60/372,048, attorney docket no. 25791.93, filed on 4/12/02, (68) U.S. patent application serial no. 10/331,718, attorney docket no. 25791.94, filed on 12/30/02, which is a divisional U.S. patent application serial no. 09/679,906, filed on 10/5/00, attorney docket no. 25791.37.02, which claims priority from provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (69) PCT application US 03/04837, filed on 2/29/03, attorney docket no. 25791.95.02, which claims priority from U.S. provisional patent application serial no. 60/363,829, attorney docket no. 25791.95, filed on 3/13/02, (70) U.S. patent application serial no. 10/261,927, attorney docket no. 25791.97, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on

6/7/99, (71) U.S. patent application serial no. 10/262,008, attorney docket no. 25791.98, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (72) U.S. patent application serial no. 10/261,925, attorney docket no. 25791.99, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (73) U.S. patent application serial no. 10/199,524, attorney docket no. 25791.100, filed on 7/19/02, which is a continuation of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (74) PCT application US 03/10144, filed on 3/28/03, attorney docket no. 25791.101.02, which claims priority from U.S. provisional patent application serial no. 60/372,632, attorney docket no. 25791.101, filed on 4/15/02, (75) U.S. provisional patent application serial no. 60/412,542, attorney docket no. 25791.102, filed on 9/20/02, (76) PCT application US 03/14153, filed on 5/6/03, attorney docket no. 25791.104.02, which claims priority from U.S. provisional patent application serial no. 60/380,147, attorney docket no. 25791.104, filed on 5/6/02, (77) PCT application US 03/19993, filed on 6/24/03, attorney docket no. 25791.106.02, which claims priority from U.S. provisional patent application serial no. 60/397,284, attorney docket no. 25791.106, filed on 7/19/02, (78) PCT application US 03/13787, filed on 5/5/03, attorney docket no. 25791.107.02, which claims priority from U.S. provisional patent application serial no. 60/387,486, attorney docket no. 25791.107, filed on 6/10/02, (79) PCT application US 03/18530, filed on 6/11/03, attorney docket no. 25791.108.02, which claims priority from U.S. provisional patent application serial no. 60/387,961, attorney docket no. 25791.108, filed on 6/12/02, (80) PCT application US 03/20694, filed on 7/1/03, attorney docket no. 25791.110.02, which claims priority from U.S. provisional patent application serial no. 60/398,061, attorney docket no. 25791.110, filed on 7/24/02, (81) PCT application US 03/20870, filed on 7/2/03, attorney docket no. 25791.111.02, which claims priority from U.S. provisional patent application serial no. 60/399,240, attorney docket no. 25791.111, filed on 7/29/02, (82) U.S. provisional patent application serial no. 60/412,487, attorney docket no. 25791.112, filed on 9/20/02, (83) U.S. provisional patent application serial no. 60/412,488, attorney docket no. 25791.114, filed on 9/20/02, (84) U.S. patent application serial no. 10/280,356, attorney docket no. 25791.115, filed on 10/25/02, which is a continuation of U.S. patent number 6,470,966, which was filed as patent application serial number 09/850,093, filed on 5/7/01, attorney docket no. 25791.55, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (85) U.S. provisional patent application serial no. 60/412,177, attorney docket no. 25791.117, filed on 9/20/02, (86) U.S. provisional patent application serial no. 60/412,653, attorney docket no. 25791.118, filed on 9/20/02, (87) U.S. provisional patent application serial no. 60/405,610, attorney docket no. 25791.119, filed on 8/23/02, (88) U.S. provisional patent application serial no. 60/405,394, attorney docket no. 25791.120, filed on 8/23/02, (89) U.S. provisional patent application serial no. 60/412,544, attorney docket no. 25791.121, filed on 9/20/02, (90) PCT application US 03/24779, filed on 8/8/03, attorney docket no. 25791.125.02, which claims priority from U.S. provisional patent application serial no. 60/407,442, attorney docket no. 25791.125, filed on 8/30/02, (91) U.S. provisional patent application serial no. 60/423,363, attorney docket no. 25791.126, filed on 12/10/02, (92) U.S. provisional patent application serial no. 60/412,196, attorney docket no. 25791.127, filed on 9/20/02, (93) U.S. provisional patent application serial no. 60/412,187, attorney docket no. 25791.128, filed on 9/20/02, (94) U.S.

provisional patent application serial no. 60/412,371, attorney docket no. 25791.129, filed on 9/20/02, (95) U.S. patent application serial no. 10/382,325, attorney docket no. 25791.145, filed on 3/5/03, which is a continuation of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (96) U.S. patent application serial no. 10/624,842, attorney docket no. 25791.151, filed on 7/22/03, which is a divisional of U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, which claims priority from provisional application 60/119,611, filed on 2/11/99, (97) U.S. provisional patent application serial no. 60/431,184, attorney docket no. 25791.157, filed on 12/5/02, (98) U.S. provisional patent application serial no. 60/448,526, attorney docket no. 25791.185, filed on 2/18/03, (99) U.S. provisional patent application serial no. 60/461,539, attorney docket no. 25791.186, filed on 4/9/03, (100) U.S. provisional patent application serial no. 60/462,750, attorney docket no. 25791.193, filed on 4/14/03, (101) U.S. provisional patent application serial no. 60/436,106, attorney docket no. 25791.200, filed on 12/23/02, (102) U.S. provisional patent application serial no. 60/442,942, attorney docket no. 25791.213, filed on 1/27/03, (103) U.S. provisional patent application serial no. 60/442,938, attorney docket no. 25791.225, filed on 1/27/03, (104) U.S. provisional patent application serial no. 60/418,687, attorney docket no. 25791.228, filed on 4/18/03, (105) U.S. provisional patent application serial no. 60/454,896, attorney docket no. 25791.236, filed on 3/14/03, (106) U.S. provisional patent application serial no. 60/450,504, attorney docket no. 25791.238, filed on 2/26/03, (107) U.S. provisional patent application serial no. 60/451,152, attorney docket no. 25791.239, filed on 3/9/03, (108) U.S. provisional patent application serial no. 60/455,124, attorney docket no. 25791.241, filed on 3/17/03, (109) U.S. provisional patent application serial no. 60/453,678, attorney docket no. 25791.253, filed on 3/11/03, (110) U.S. patent application serial no. 10/421,682, attorney docket no. 25791.256, filed on 4/23/03, which is a continuation of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99, (111) U.S. provisional patent application serial no. 60/457,965, attorney docket no. 25791.260, filed on 3/27/03, (112) U.S. provisional patent application serial no. 60/455,718, attorney docket no. 25791.262, filed on 3/18/03, (113) U.S. patent number 6,550,821, which was filed as patent application serial no. 09/811,734, filed on 3/19/01, (114) U.S. patent application serial no. 10/436,467, attorney docket no. 25791.268, filed on 5/12/03, which is a continuation of U.S. patent number 6,604,763, which was filed as application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, which claims priority from provisional application 60/131,106, filed on 4/26/99, (115) U.S. provisional patent application serial no. 60/459,776, attorney docket no. 25791.270, filed on 4/2/03, (116) U.S. provisional patent application serial no. 60/461,094, attorney docket no. 25791.272, filed on 4/8/03, (117) U.S. provisional patent application serial no. 60/461,038, attorney docket no. 25791.273, filed on 4/7/03, (118) U.S. provisional patent application serial no. 60/463,586, attorney docket no. 25791.277, filed on 4/17/03, (119) U.S. provisional patent application serial no. 60/472,240, attorney docket no. 25791.286, filed on 5/20/03, (120) U.S. patent application serial no. 10/619,285, attorney docket no. 25791.292, filed on 7/14/03, which is a continuation-in-part of U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, (now U.S. Patent 6,634,431 which issued 10/21/2003), which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (121) U.S. utility patent application serial no. 10/418,688, attorney docket no. 25791.257, which was filed on 4/18/03, as a division of U.S. utility patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed

on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99; (122) PCT patent application serial no. PCT/US2004/06246, attor ney docket no. 25791.238.02, filed on 2/26/2004; (123) PCT patent application serial number PCT/US2004/08170, attorney docket number 25791.40.02, filed on 3/15/04; (124) PCT patent application serial number PCT/US2004/08171, attorney docket number 25791.236.02, filed on 3/15/04; (125) PCT patent application serial number PCT/US2004/08073, attorney docket number 25791.262.02, filed on 3/18/04; (126) PCT patent application serial number PCT/US2004/07711, attorney docket number 25791.253.02, filed on 3/11/2004; (127) PCT patent application serial number PCT/US2004/029025, attorney docket number 25791.260.02, filed on 3/26/2004; (128) PCT patent application serial number PCT/US2004/010317, attorney docket number 25791.270.02, filed on 4/2/2004; (129) PCT patent application serial number PCT/US2004/010712, attorney docket number 25791.272.02, filed on 4/6/2004; (130) PCT patent application serial number PCT/US2004/010762, attorney docket number 25791.273.02, filed on 4/6/2004; (131) PCT patent application serial number PCT/US2004/011973, attorney docket number 25791.277.02, filed on 4/15/2004; (132) U.S. provisional patent application serial number 60/495056, attorney docket number 25791.301, filed on 8/14/2003; (133) U.S. provisional patent application serial number 60/600679, attorney docket number 25791.194, filed on 8/11/2004; (134) PCT patent application serial number PCT/US2005/027318, attorney docket number 25791.329.02, filed on 7/29/2005; (135) PCT patent application serial number PCT/US2005/028936, attorney docket number 25791.338.02, filed on 8/12/2005; (136) PCT patent application serial number PCT/US2005/028669, attorney docket number 25791.194.02, filed on 8/11/2005; (137) PCT patent application serial number PCT/US2005/028453, attorney docket number 25791.371, filed on 8/11/2005; (138) PCT patent application serial number PCT/US2005/028641, attorney docket number 25791.372, filed on 8/11/2005; (139) PCT patent application serial number PCT/US2005/028819, attorney docket number 25791.373, filed on 8/11/2005; (140) PCT patent application serial number PCT/US2005/028446, attorney docket number 25791.374, filed on 8/11/2005; (141) PCT patent application serial number PCT/US2005/028642, attorney docket number 25791.375, filed on 8/11/2005; (142) PCT patent application serial number PCT/US2005/028451, attorney docket number 25791.376, filed on 8/11/2005, and (143). PCT patent application serial number PCT/US2005/028473, attorney docket number 25791.377, filed on 8/11/2005, (144) U.S. utility patent application serial number 10/546082, attorney docket number 25791.378, filed on 8/16/2005, (145) U.S. utility patent application serial number 10/546076, attorney docket number 25791.379, filed on 8/16/2005, (146) U.S. utility patent application serial number 10/545936, attorney docket number 25791.380, filed on 8/16/2005, (147) U.S. utility patent application serial number 10/546079, attorney docket number 25791.381, filed on 8/16/2005 (148) U.S. utility patent application serial number 10/545941, attorney docket number 25791.382, filed on 8/16/2005, (149) U.S. utility patent application serial number 546078, attorney docket number 25791.383, filed on 8/16/2005, filed on 8/11/2005., (150) U.S. utility patent application serial number 10/545941, attorney docket number 25791.185.05, filed on 8/16/2005, (151) U.S. utility patent application serial number 11/249967, attorney docket number 25791.384, filed on 10/13//2005, (152) U.S. provisional patent application serial number 60/734302, attorney docket number 25791.24, filed on 11/7/2005, (153) U.S. provisional patent application serial number 60/725181, attorney docket number 25791.184, filed on 10/11/2005, (154) PCT patent application serial number PCT/US2005/023391, attorney docket number 25791.299.02 filed 6/29/2005 which claims priority from U.S. provisional patent application serial number 60/585370, attorney docket number 25791.299, filed on 7/2/2004, (155) U.S. provisional patent application serial number 60/721579, attorney docket number 25791.327, filed on 9/28/2005, (156) U.S. provisional patent application serial number 60/717391, attorney docket number 25791.214,

filed on 9/15/2005, (157) U.S. provisional patent application serial number 60/702935, attorney docket number 25791.133, filed on 7/27/2005, (158) U.S. provisional patent application serial number 60/663913, attorney docket number 25791.32, filed on 3/21/2005, (159) U.S. provisional patent application serial number 60/652564, attorney docket number 25791.348, filed on 2/14/2005, (160) U.S. provisional patent application serial number 60/645840, attorney docket number 25791.324, filed on 1/21/2005, (161) PCT patent application serial number PCT/US2005/________, attorney docket number 25791.326.02, filed on 11/29/2005 which claims priority from U.S. provisional patent application serial number 60/631703, attorney docket number 25791.326, filed on 11/30/2004, (162) U.S. provisional patent application serial number __________, attorney docket number 25791.339, filed on 12/22/2005, (163) U.S. National Stage application serial no. 10/548934, attorney docket no. 25791.253.05, filed on 9/12/2005; (164) U.S. National Stage application serial no. 10/549410, attorney docket no. 25791.262.05, filed on 9/13/2005; (165) U.S. Provisional Patent Application No. 60/717391, attorney docket no. 25791.214 filed on 9/15/2005; (166) U.S. National Stage application serial no. 10/550906, attorney docket no. 25791.260.06, filed on 9/27/2005; (167) U.S. National Stage application serial no. 10/551880, attorney docket no. 25791.270.06, filed on 9/30/2005; (168) U.S. National Stage application serial no. 10/552253, attorney docket no. 25791.273.06, filed on 10/4/2005; (169) U.S. National Stage application serial no. 10/552790, attorney docket no. 25791.272.06, filed on 10/11/2005; (170) U.S. Provisional Patent Application No. 60/725181, attorney docket no. 25791.184 filed on 10/11/2005; (171) U.S. National Stage application serial no. 10/553094, attorney docket no. 25791.193.03, filed on 10/13/2005; (172) U.S. National Stage application serial no. 10/553566, attorney docket no. 25791.277.06, filed on 10/17/05; (173) PCT Patent Application No. PCT/US2006/_________, attorney docket no. 25791.324.02 filed on 1/20/06, and (174) PCT Patent Application No. PCT/US2006/_________, attorney docket no. 25791.348.02 filed on 2/9/06; (175) U.S. Utility Patent application serial no. _________________, attorney docket no. 25791.386, filed on 2/17/06, (176) U.S. National Stage application serial no. _________, attorney docket no. 25791.301.06, filed on ________, (177) U.S. National Stage application serial no. ___________, attorney docket no. 25791.137.04, filed on __________, (178) U.S. National Stage application serial no. ___________, attorney docket no. 25791.215.06, filed on __________.

[000398] It is understood that variations may be made in the foregoing without departing from the scope of the invention. For example, the teachings of the present illustrative embodiments may be used to provide a wellbore casing, a pipeline, or a structural support. Furthermore, one or more of tubular members such as, for example, the tubular members 2316, 2600, or 2700a and 2700b, described above with reference to Figs. 21a, 25a, and 25b, may be slotted, perforated, or otherwise include one or more radial passages.

[000399] In several exemplary embodiment, the apparatus 200, 300, 400, and 800, the assemblies 500, 600, 700, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, and 2200, and the devices 2314, 2414, 2500, 2900, 3000, 3100, 3200, 3300, 3400, 3500, 3600, 3700, 3802, 3900, 4002, and 4102 may provide an adjustable and/or adaptable system for expanding a tubular member.

[000400] An expansion apparatus has been described that includes an expansion device operable to expand an expandable tubular member including an expansion device segment for defining an outer surface of the expansion device, and a cam movingly coupled to the expansion device segment, wherein the cam is operable to be rotated from a first position to define the outer surface in a first small diameter configuration, and a second position to define the outer surface in a second large diameter configuration. In an exemplary embodiment, the expansion device includes a plurality of expansion device segments. In an exemplary embodiment, the cam is movingly coupled to the plurality of expansion device segments. In an exemplary embodiment, the expansion device includes

a plurality of cams movingly coupled to the plurality of expansion device segments. In an exemplary embodiment, the plurality of expansion device segments and the plurality of cams include a first cam movingly coupled to a first plurality of expansion device segments and a second cam movingly coupled to a second plurality of expansion device segments, whereby the first cam and first plurality of expansion device segments are offset along a length of the expansion device from the second cam and second plurality of expansion device segments. In an exemplary embodiment, the expansion device segment is pivotally coupled to a support structure on the expansion device. In an exemplary embodiment, the plurality of expansion device segments are coupled to a support structure which is operable to allow the plurality of expansion device segments to translate laterally relative to each other upon operation of the cam. In an exemplary embodiment, each of the plurality of expansion device segments are slidingly coupled to adjacent expansion device segments. In an exemplary embodiment, the expansion device segment includes an expansion device roller. In an exemplary embodiment, the plurality of expansion device segments includes a first plurality of expansion device segments which are interlaced with a second plurality of expansion device segments. In an exemplary embodiment, an expansion system is coupled to the expansion device for adaptively expanding the expansion device which includes a controller coupled to the expansion device, a sensor coupled to the controller, and a user interface coupled to the controller. In an exemplary embodiment, a driving mechanism is coupled to the cam. In an exemplary embodiment, a motor is coupled to the driving mechanism. In an exemplary embodiment, an expandable tubular member is included which is operable to be expanded by the expansion device, whereby the expansion device is positioned within the expandable tubular member.

[000401] An expansion apparatus has been described which includes an expansion device operable to expand an expandable tubular member including a mandrel which is operable to be connected to a string, a plurality of expansion device segments movingly mounted to the mandrel and defining an outer surface of the expansion device, a first collet mounted on the mandrel, positioned above the plurality of expansion device segments, and operable to engage the plurality of expansion device segments, and a second collet mounted on the mandrel, positioned below the plurality of expansion portions, and operable to engage the plurality of expansion device segments, whereby the outer surface is configured in a first small diameter configuration in response to the first collet and the second collet being positioned in a first position, and the outer surface is configured in a second large diameter configuration in response to the first collet and the second collet engaging the plurality of expansion device segments and being positioned in a second position. In an exemplary embodiment, a driving mechanism is included for moving the collets between the first position and the second position. In an exemplary embodiment, the first collet and the second collet move along the mandrel between the first position and the second position. In an exemplary embodiment, the plurality of expansion device segments are coupled to a support structure on the mandrel which is operable to allow the expansion device segments to translate laterally relative to each other upon operation of the first collet and the second collet. In an exemplary embodiment, an expandable tubular member is included, whereby the expansion device is positioned within the expandable tubular member.

[000402] An expansion apparatus has been described which includes an expansion device operable to expand an expandable tubular member including a support member, a first piston actuation structure mounted on the support member, a second piston actuation structure mounted on the support member, a first axle mounted between the first piston actuation structure and the second piston actuation structure, and an expansion device segment mounted on the first axle and defining an outer surface of the expansion device, whereby the first piston actuation structure and the second piston actuation structure are operable to be actuated to configure the outer surface in one of either a first small diameter configuration and a second large diameter configuration. In an exemplary embodiment, a first fluid

passage is included between the first piston actuation structure and an interior of the support member, and a second fluid passage is included between the second piston actuation structure and the interior of the support member. In an exemplary embodiment, a second axle is mounted between the first piston actuation structure and the second piston actuation structure, and a expansion device segment is mounted on the second axle. In an exemplary embodiment, the expansion device segment includes an expansion device roller. In an exemplary embodiment, an expandable tubular member is included, whereby the expansion device is positioned within the expandable tubular member.

[000403] An expansion apparatus has been described which includes an expansion device operable to expand an expandable tubular member, the expansion device including a bladder comprising an interior of the expansion device, and a device outer skin exterior to the bladder, whereby the bladder is operable to expand the device outer skin from a first small diameter configuration to a second large diameter configuration. In an exemplary embodiment, a plurality of inserts are included exterior to the device outer skin. In an exemplary embodiment, a support member is included, wherein the expansion device is mounted on the support member. In an exemplary embodiment, a fluid passage is included between an interior of the support member and the bladder. In an exemplary embodiment, the device outer skin includes a metal. In an exemplary embodiment, an expandable tubular member is included, whereby the expansion device is positioned within the expandable tubular member.

[000404] An expansion apparatus has been described which includes an expansion device operable to expand an expandable tubular member, the expansion device including a plurality of small sections, and a plurality of large sections, whereby each small section is positioned between two adjacent large sections, each large section is positioned between two adjacent small sections, and the plurality of small sections and the plurality of large sections are expandable from a first small diameter configuration to a second large diameter configuration. In an exemplary embodiment, a support mandrel is included to hold the plurality of small sections and the plurality of large sections in the second large diameter configuration. In an exemplary embodiment, a retaining sleeve is included to hold the plurality of small sections and the plurality of large sections in the first small diameter configuration. In an exemplary embodiment, a section retainer is included, whereby the plurality of small sections and the plurality of large sections are pivotally mounted to the section retainer. In an exemplary embodiment, a section retainer is included, whereby the plurality of small sections and the plurality of large sections are cantilevered off of the section retainer. In an exemplary embodiment, an expandable tubular member is included, whereby the expansion device is positioned within the expandable tubular member.

[000405] An expansion apparatus has been described which includes an expansion device operable to expand an expandable tubular member, the expansion device including a support structure, expansion means for defining an outer surface of the expansion device which is coupled to the support structure, and control means for positioning the expansion means between a first small diameter configuration and a second large diameter configuration.

[000406] A method for expanding a tubular member has been described that includes providing an expansion device including a plurality of expansion device segments which define an outer surface of the expansion device, movingly coupling a cam to the plurality of expansion device segments, configuring the expansion device segments in a first small diameter configuration by rotating the cam, positioning the expansion device in an expandable tubular member, configuring the expansion device segments in a second large diameter configuration by rotating the cam, and expanding the expandable tubular member by displacing the expansion device through the expandable tubular member.

[000407] A method for expanding a tubular member has been described that includes providing an expansion

device including a plurality of expansion device segments which define an outer surface of the expansion device, movingly coupling a plurality of collets to the plurality of expansion device segments, configuring the expansion device segments in a first small diameter configuration by moving the plurality of collets, positioning the expansion device in an expandable tubular member, configuring the expansion device segments in a second large diameter configuration by moving the plurality of collets, and expanding the expandable tubular member by displacing the expansion device through the expandable tubular member.

[000408] A method for expanding a tubular member has been described that includes providing an expansion device including a plurality of expansion device segments which define an outer surface of the expansion device, coupling the plurality of expansion device segments to a plurality of piston type actuators, configuring the expansion device segments in a first small diameter configuration by actuating the piston type actuators, positioning the expansion device in an expandable tubular member, configuring the expansion device segments in a second large diameter configuration by actuating the piston type actuators, and expanding the expandable tubular member by displacing the expansion device through the expandable tubular member.

[000409] A method for expanding a tubular member has been described that includes providing an expansion device including a bladder and an outer device skin which defines an outer surface of the expansion device, configuring the expansion device segments in a first small diameter configuration by removing a fluid from the bladder, positioning the expansion device in an expandable tubular member, configuring the expansion device segments in a second large diameter configuration by adding fluid to the bladder, and expanding the expandable tubular member by displacing the expansion device through the expandable tubular member.

[000410] A method for expanding a tubular member has been described that includes providing an expansion device including a plurality of small sections and a plurality of large sections, whereby each small section is positioned between two adjacent large sections, each large section is positioned between two adjacent small sections, and the plurality of small sections and the plurality of large sections are expandable from a first small diameter configuration to a second large diameter configuration, configuring the expansion device segments in the first small diameter configuration by holding the small sections and the large sections in the first small diameter configuration with the use of a retaining sleeve, positioning the expansion device in an expandable tubular member, configuring the expansion device segments in a second large diameter configuration by engaging the small sections and the large sections with a support mandrel, and expanding the expandable tubular member by displacing the expansion device through the expandable tubular member.

[000411] An apparatus has been described which includes an expandable tubular member, and an expansion sleeve coupled to the expandable tubular member which is operable to decouple from the expandable tubular member and couple to an expansion device in order to increase an outside diameter of the expansion device. In an exemplary embodiment, a plurality of shear pins are included for coupling the expansion sleeve to the expandable tubular member. In an exemplary embodiment, an expansion device is positioned in the expandable tubular member and operable to couple to the expansion sleeve to expand from a first small diameter configuration to a second large diameter configuration.

[000412] An expansion apparatus has been described that includes an expandable tubular member, and expansion means coupled to the expandable tubular member for increasing the outside diameter of an expansion device.

[000413] A method for expanding an expandable tubular member has been described that includes providing an expandable tubular member, coupling an expansion sleeve to the expandable tubular member, positioning an

expansion device in the expandable tubular member, displacing the expansion device through the expandable tubular member, increasing the outside diameter of the expansion device by engaging the expansion device with the expansion sleeve and coupling the expansion sleeve to the expansion device while decoupling the expansion sleeve from the expandable tubular member, and expanding the expandable tubular member by displacing the expansion device with the expansion sleeve through the expandable tubular member.

[000414] An expansion apparatus has been described that includes an expansion device comprising a working outer surface, and a laser cladded coating on the working outer surface. In an exemplary embodiment, the laser cladded coating has a thickness of approximately 0.020 inches to 0.100 inches. In an exemplary embodiment, the laser cladded coating includes at least one section having a substantially greater thickness than the rest of the laser cladded coating positioned on an area of the expansion device likely to experience greater wear. In an exemplary embodiment, the laser cladded coating increases the resistance of the expansion device from galling. In an exemplary embodiment, a diamond coating layer is included on the laser cladded coating. In an exemplary embodiment, the diamond coating layer decreases the coefficient of the expansion device.

[000415] A method for expanding an expandable tubular member has been described that includes providing an expandable tubular member, providing an expansion device including an outer expansion surface, coating the outer expansion surface with a layer of material by laser-cladding, positioning the expansion device in the expandable tubular member, and expanding the expandable tubular member by displacing the expansion device through the expandable tubular member. In an exemplary embodiment, the method further includes coating the layer of material with a diamond coating. In an exemplary embodiment, the method further includes reducing the coefficient of friction between the expandable tubular member and the expansion device by coating the layer of material with a diamond coating.

[000416] The teachings of the present illustrate embodiments may, for example, be applied to well construction and repair, pipeline construction and repair, and/or building construction and repair.

[000417] Although illustrative embodiments of the invention have been shown and described, a wide range of modification, changes and substitution is contemplated in the foregoing disclosure. In some instances, some features of the present invention may be employed without a corresponding use of the other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.

## Claims

What is claimed is:

1. An expansion apparatus, comprising:

an expansion device operable to expand an expandable tubular member comprising:

an expansion device segment for defining an outer surface of the expansion device; and

a cam movingly coupled to the expansion device segment, wherein the cam is operable to be rotated from a first position to define the outer surface in a first small diameter configuration, and a second position to define the outer surface in a second large diameter configuration.

2. The apparatus of claim 1, wherein the expansion device includes a plurality of expansion device segments.

3. The apparatus of claim 2, wherein the cam is movingly coupled to the plurality of expansion device segments.

4. The apparatus of claim 2, wherein the expansion device includes a plurality of cams movingly coupled to the plurality of expansion device segments.

5. The apparatus of claim 4, wherein the plurality of expansion device segments and the plurality of cams comprise a first cam movingly coupled to a first plurality of expansion device segments and a second cam movingly coupled to a second plurality of expansion device segments, whereby the first cam and first plurality of expansion device segments are offset along a length of the expansion device from the second cam and second plurality of expansion device segments.

6. The apparatus of claim 1, wherein the expansion device segment is pivotally coupled to a support structure on the expansion device.

7. The apparatus of claim 2, wherein the plurality of expansion device segments are coupled to a support structure which is operable to allow the plurality of expansion device segments to translate laterally relative to each other upon operation of the cam.

8. The apparatus of claim 2, wherein each of the plurality of expansion device segments are slidingly coupled to adjacent expansion device segments.

9. The apparatus of claim 1, wherein the expansion device segment includes an expansion device roller.

10. The apparatus of claim 2, wherein the plurality of expansion device segments includes a first plurality of expansion device segments which are interlaced with a second plurality of expansion device segments.

11. The apparatus of claim 1, further comprising:

an expansion system coupled to the expansion device for adaptively expanding the expansion device comprising:

a controller coupled to the expansion device;

a sensor coupled to the controller; and

a user interface coupled to the controller.

12. The apparatus of claim 1, further comprising:

a driving mechanism coupled to the cam.

13. The apparatus of claim 12, further comprising:

a motor coupled to the driving mechanism.

14. The apparatus of claim 12, further comprising:

an expandable tubular member operable to be expanded by the expansion device,

whereby the expansion device is positioned within the expandable tubular member.

15. An expansion apparatus, comprising:

an expansion device operable to expand an expandable tubular member comprising:

a mandrel which is operable to be connected to a string;

a plurality of expansion device segments movingly mounted to the mandrel and defining an outer surface of the expansion device;

a first collet mounted on the mandrel, positioned above the plurality of expansion device segments, and operable to engage the plurality of expansion device segments; and

a second collet mounted on the mandrel, positioned below the plurality of expansion portions, and operable to engage the plurality of expansion device segments, whereby the outer surface is configured in a first small diameter configuration in response to the first collet and the second collet being positioned in a first position, and the outer surface is configured in a second large diameter configuration in response to the first collet and the second collet engaging the plurality of expansion device segments and being positioned in a second position.

16. The apparatus of claim 15, further comprising:

a driving mechanism for moving the collets between the first position and the second position.

17. The apparatus of claim 15, wherein the first collet and the second collet move along the mandrel between the first position and the second position.

18. The apparatus of claim 15, wherein the plurality of expansion device segments are coupled to a support structure on the mandrel which is operable to allow the expansion device segments to translate laterally relative to each other upon operation of the first collet and the second collet.

19. The apparatus of claim 15, further comprising:

an expandable tubular member, whereby the expansion device is positioned within the expandable tubular member.

20. An expansion apparatus, comprising:

an expansion device operable to expand an expandable tubular member comprising:

a support member;

a first piston actuation structure mounted on the support member;

a second piston actuation structure mounted on the support member;

a first axle mounted between the first piston actuation structure and the second piston actuation structure; and

an expansion device segment mounted on the first axle and defining an outer surface of the expansion device, whereby the first piston actuation structure and the second piston actuation structure are operable to be actuated to configure the outer surface in one of either a first small diameter configuration and a second large diameter configuration.

21. The apparatus of claim 20, further comprising:

a first fluid passage between the first piston actuation structure and an interior of the support member, and a second fluid passage between the second piston actuation structure and the interior of the support member.

22. The apparatus of claim 20, further comprising:

a second axle mounted between the first piston actuation structure and the second piston actuation structure, and a expansion device segment mounted on the second axle.

23. The apparatus of claim 20, wherein the expansion device segment includes an expansion device roller.

24. The apparatus of claim 20, further comprising:

an expandable tubular member, whereby the expansion device is positioned within the expandable tubular member.

25. An expansion apparatus, comprising:

an expansion device operable to expand an expandable tubular member, the expansion device comprising:

a bladder comprising an interior of the expansion device; and

a device outer skin exterior to the bladder, whereby the bladder is operable to expand the device outer skin from a first small diameter configuration to a second large diameter configuration.

26. The apparatus of claim 25, further comprising:

a plurality of inserts exterior to the device outer skin.

27. The apparatus of claim 25, further comprising:

a support member, wherein the expansion device is mounted on the support member.

28. The apparatus of claim 27, further comprising:

a fluid passage between an interior of the support member and the bladder.

29. The apparatus of claim 25, wherein the device outer skin includes a metal.

30. The apparatus of claim 25, further comprising:

an expandable tubular member, whereby the expansion device is positioned within the expandable tubular member.

31. An expansion apparatus, comprising:

an expansion device operable to expand an expandable tubular member, the expansion device comprising:

a plurality of small sections; and

a plurality of large sections, whereby each small section is positioned between two adjacent large sections, each large section is positioned between two adjacent small sections, and the plurality of small sections and the plurality of large sections are expandable from a first small diameter configuration to a second large diameter configuration.

32. The apparatus of claim 31, further comprising:

a support mandrel to hold the plurality of small sections and the plurality of large sections in the second large diameter configuration.

33. The apparatus of claim 31, further comprising:

a retaining sleeve to hold the plurality of small sections and the plurality of large sections in the first small diameter configuration.

34. The apparatus of claim 31, further comprising:

a section retainer, whereby the plurality of small sections and the plurality of large sections are pivotally mounted to the section retainer.

35. The apparatus of claim 31, further comprising:

a section retainer, whereby the plurality of small sections and the plurality of large sections are cantilevered off of the section retainer.

36. The apparatus of claim 31, further comprising:

an expandable tubular member, whereby the expansion device is positioned within the expandable tubular member.

38. A method for expanding a tubular member, comprising:

providing an expansion device including a plurality of expansion device segments which define an outer surface of the expansion device;

movingly coupling a cam to the plurality of expansion device segments;

configuring the expansion device segments in a first small diameter configuration by rotating the cam;

positioning the expansion device in an expandable tubular member;

configuring the expansion device segments in a second large diameter configuration by rotating the cam; and

expanding the expandable tubular member by displacing the expansion device through the expandable tubular member.

39. A method for expanding a tubular member, comprising:

providing an expansion device including a plurality of expansion device segments which define an outer surface of the expansion device;

movingly coupling a plurality of collets to the plurality of expansion device segments;

configuring the expansion device segments in a first small diameter configuration by moving the plurality of collets;

positioning the expansion device in an expandable tubular member;

configuring the expansion device segments in a second large diameter configuration by moving the plurality of collets; and

expanding the expandable tubular member by displacing the expansion device through the expandable tubular member.

40. A method for expanding a tubular member, comprising:

providing an expansion device including a plurality of expansion device segments which define an outer surface of the expansion device;

coupling the plurality of expansion device segments to a plurality of piston type actuators;

configuring the expansion device segments in a first small diameter configuration by actuating the piston type actuators;

positioning the expansion device in an expandable tubular member;

configuring the expansion device segments in a second large diameter configuration by actuating the piston type actuators; and

expanding the expandable tubular member by displacing the expansion device through the expandable tubular member.

41. A method for expanding a tubular member, comprising:

providing an expansion device including a bladder and an outer device skin which

defines an outer surface of the expansion device;

configuring the expansion device segments in a first small diameter configuration by removing a fluid from the bladder;

positioning the expansion device in an expandable tubular member;

configuring the expansion device segments in a second large diameter configuration by adding fluid to the bladder; and

expanding the expandable tubular member by displacing the expansion device through the expandable tubular member.

42. A method for expanding a tubular member, comprising:

providing an expansion device including a plurality of small sections and a plurality of large sections, whereby each small section is positioned between two adjacent large sections, each large section is positioned between two adjacent small sections, and the plurality of small sections and the plurality of large sections are expandable from a first small diameter configuration to a second large diameter configuration;

configuring the expansion device segments in the first small diameter configuration by holding the small sections and the large sections in the first small diameter configuration with the use of a retaining sleeve;

positioning the expansion device in an expandable tubular member;

configuring the expansion device segments in a second large diameter configuration by engaging the small sections and the large sections with a support mandrel; and

expanding the expandable tubular member by displacing the expansion device through the expandable tubular member.

43. An apparatus, comprising:

an expandable tubular member; and

an expansion sleeve coupled to the expandable tubular member which is operable to decouple from the expandable tubular member and couple to an expansion device in order to increase an outside diameter of the expansion device.

44. The apparatus of claim 43, further comprising:

a plurality of shear pins coupling the expansion sleeve to the expandable tubular member.

45. The apparatus of claim 43, further comprising:

an expansion device positioned in the expandable tubular member and operable to couple to the expansion sleeve to expand from a first small diameter configuration to a second large diameter configuration.

47. A method for expanding an expandable tubular member, comprising:

providing an expandable tubular member;

coupling an expansion sleeve to the expandable tubular member;

positioning an expansion device in the expandable tubular member;

displacing the expansion device through the expandable tubular member;

increasing the outside diameter of the expansion device by engaging the expansion device with the expansion sleeve and coupling the expansion sleeve to the expansion device while

decoupling the expansion sleeve from the expandable tubular member; and

expanding the expandable tubular member by displacing the expansion device with the expansion sleeve through the expandable tubular member.

48. An expansion apparatus, comprising:

an expansion device comprising a working outer surface; and

a laser cladded coating on the working outer surface.

49. The apparatus of claim 48, wherein the laser cladded coating comprises a thickness of approximately 0.020 inches to 0.100 inches.

50. The apparatus of claim 48, wherein the laser cladded coating comprises at least one section having a substantially greater thickness than the rest of the laser cladded coating positioned on an area of the expansion device likely to experience greater wear.

51. The apparatus of claim 48, wherein the laser cladded coating increases the resistance of the expansion device from galling.

52. The apparatus of claim 48, further comprising:

a diamond coating layer on the laser cladded coating.

53. The apparatus of claim 52, wherein the diamond coating layer decreases the coefficient of the expansion device.

54. A method for expanding an expandable tubular member, comprising:

providing an expandable tubular member;

providing an expansion device including an outer expansion surface;

coating the outer expansion surface with a layer of material by laser-cladding;

positioning the expansion device in the expandable tubular member; and

expanding the expandable tubular member by displacing the expansion device through the expandable tubular member.

55. The method of claim 54, further comprising:

coating the layer of material with a diamond coating.

56. The method of claim 54, further comprising:

reducing the coefficient of friction between the expandable tubular member and the expansion device by coating the layer of material with a diamond coating.

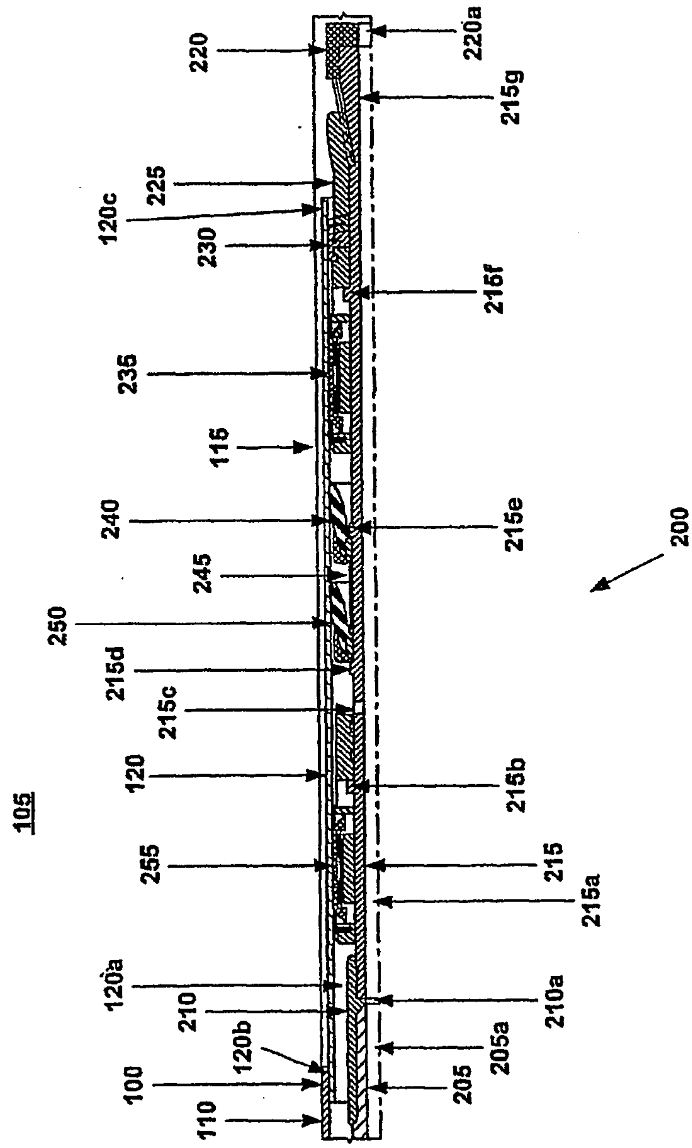
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Fig. 1

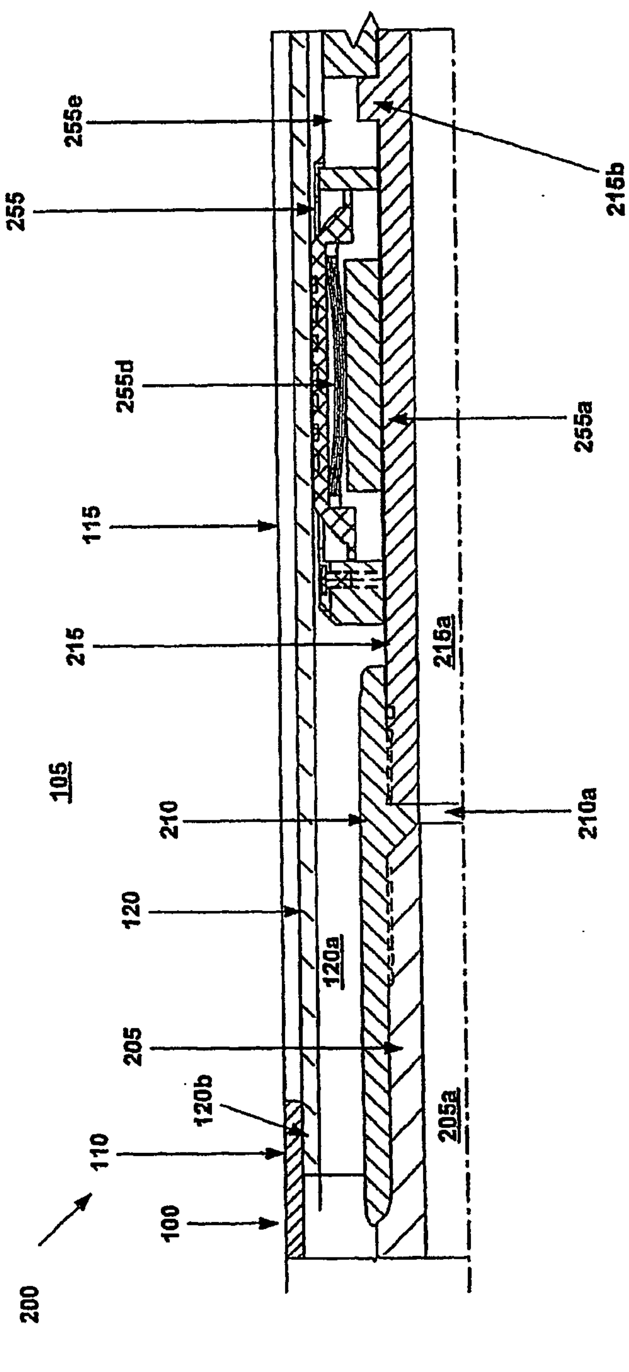
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Fig. 1a

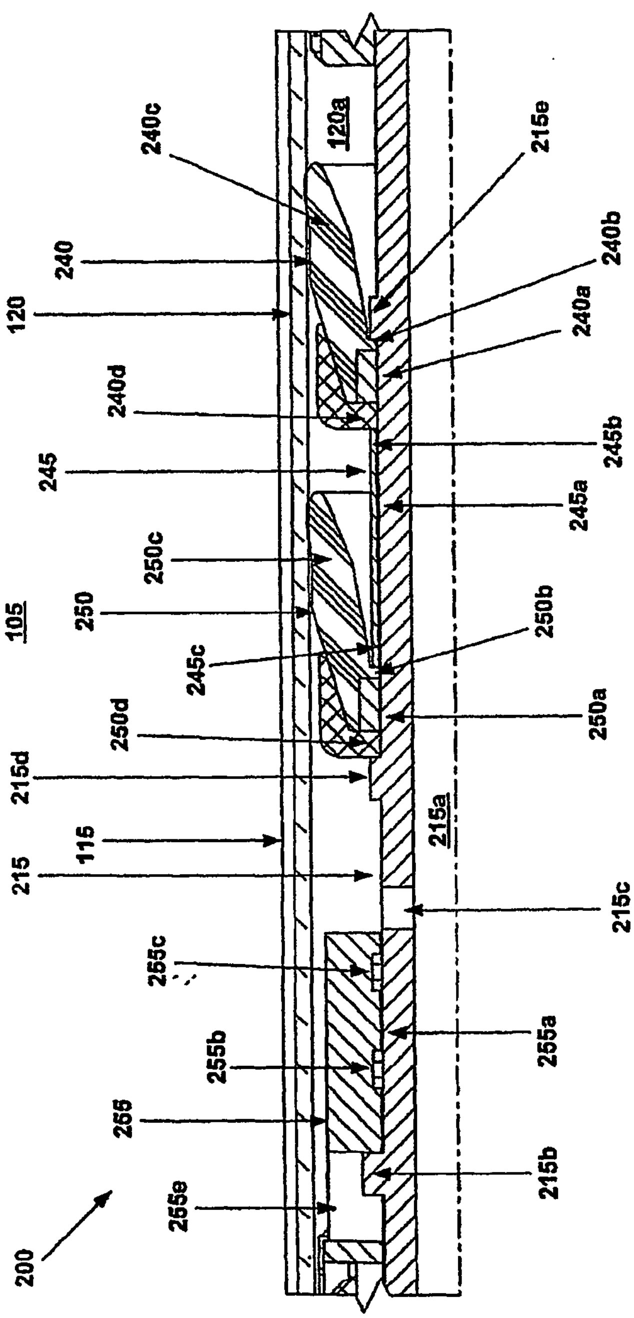
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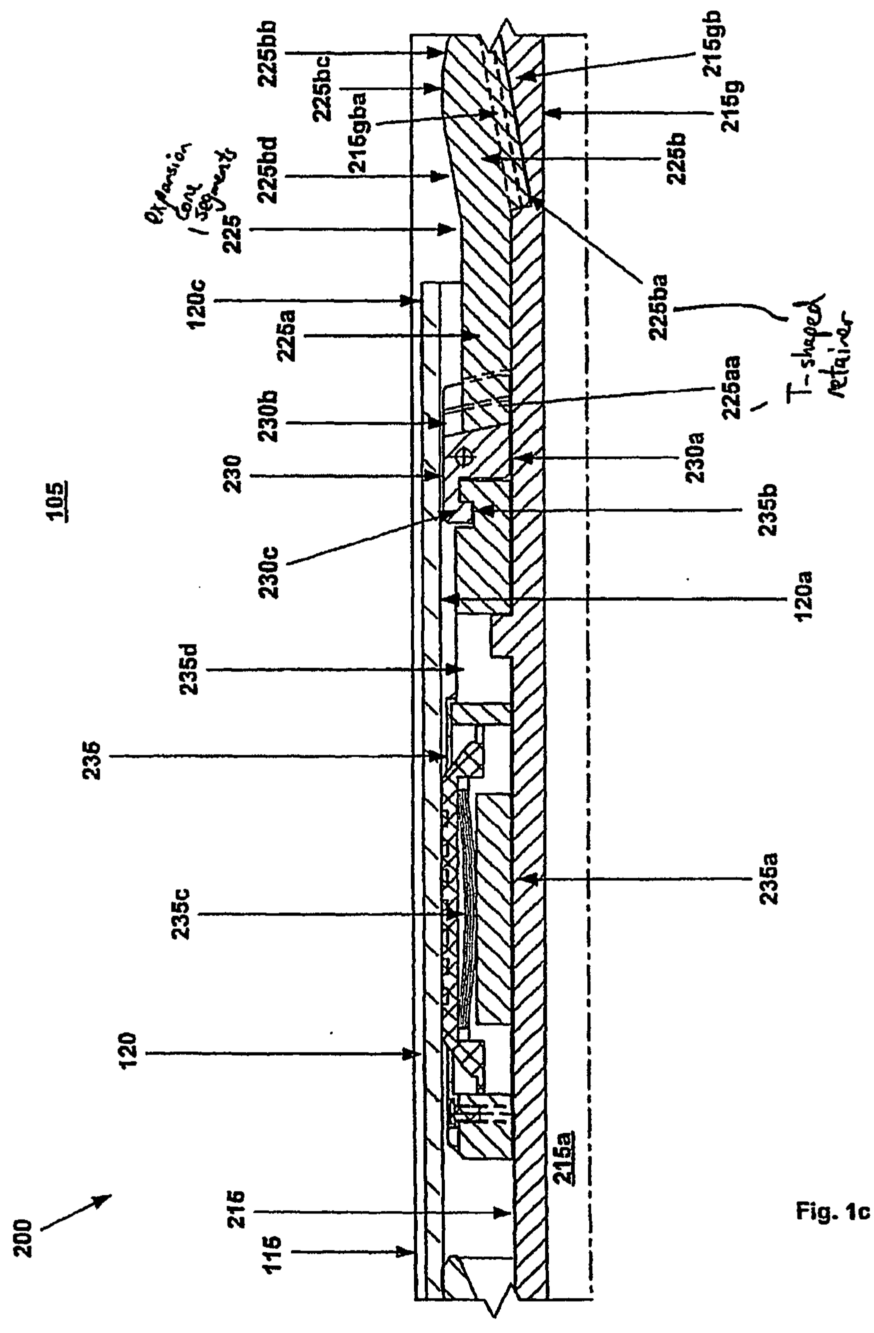
Fig. 1b



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T-shaped retainer
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Fig. 1c

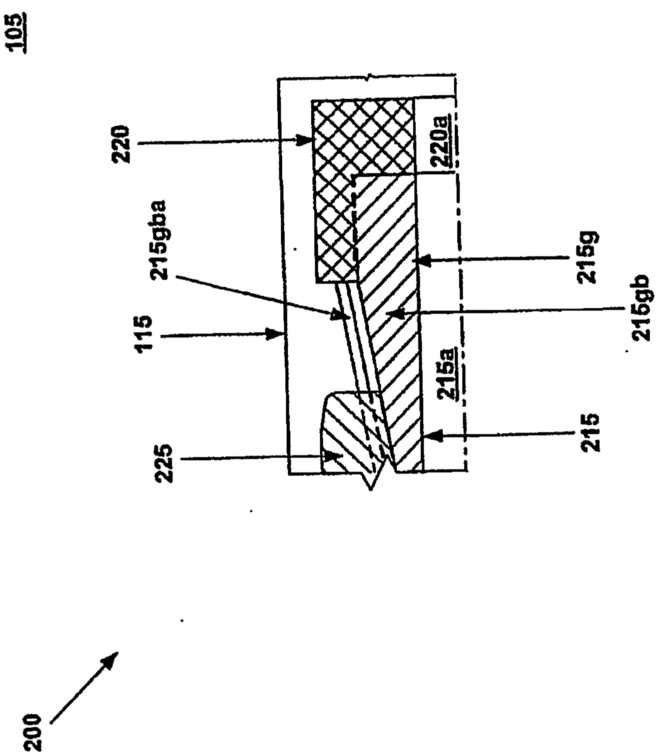


Fig. 1d

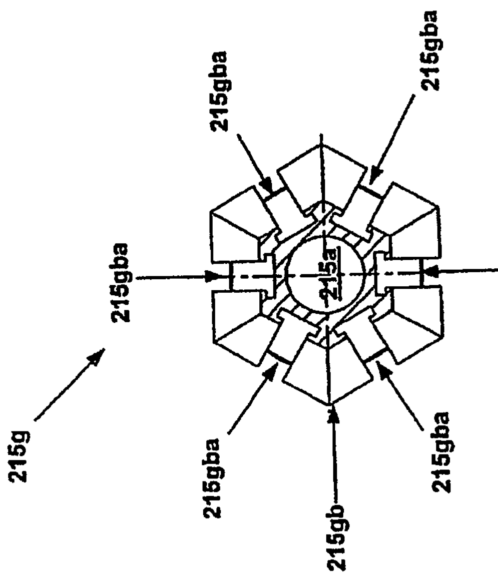
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Fig. 1f

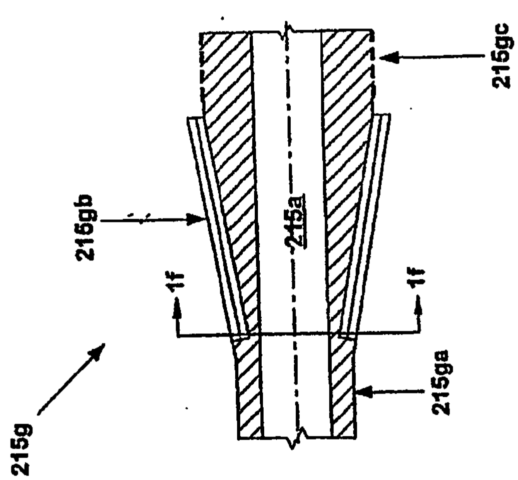
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Fig. 1e

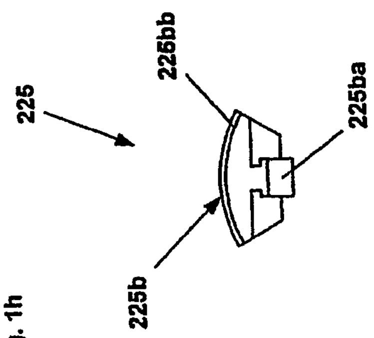


Fig. 1h

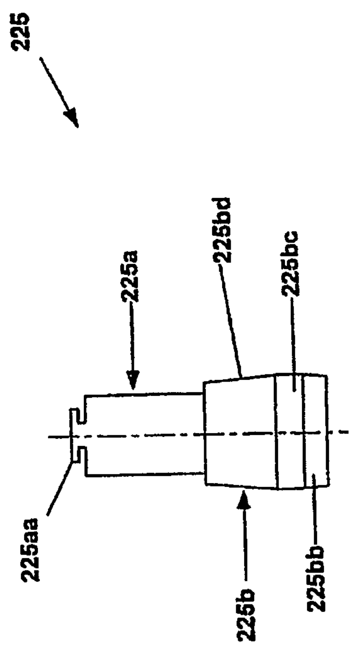


Fig. 1i

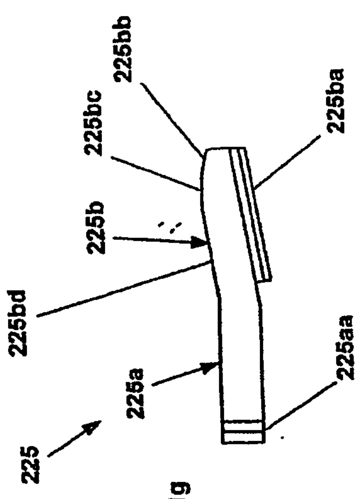


Fig. 1g

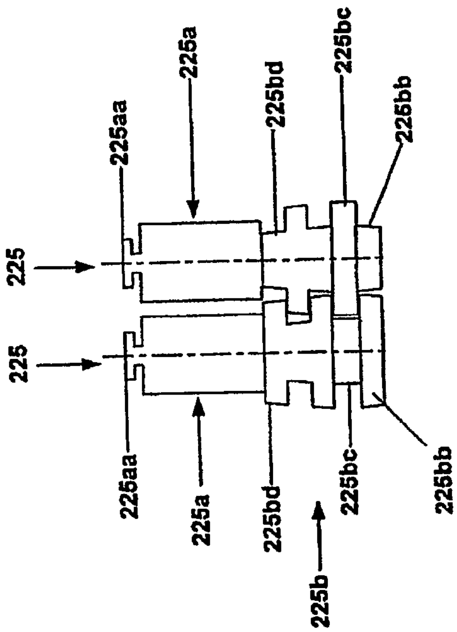
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Fig. 1j

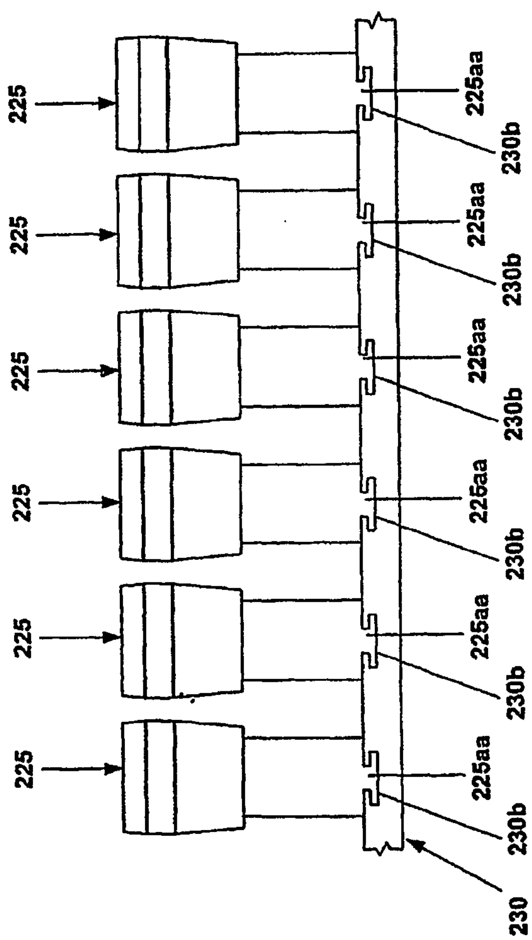
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Fig. 1k

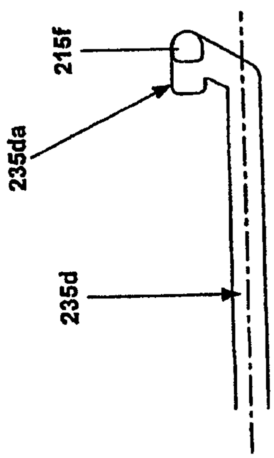


Fig. 1m

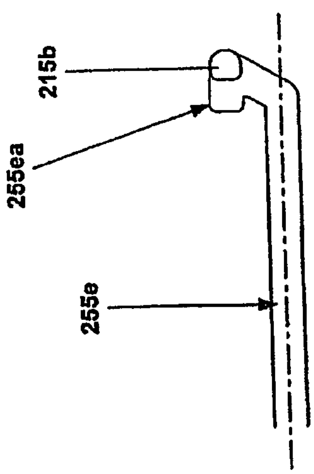


Fig. 1l

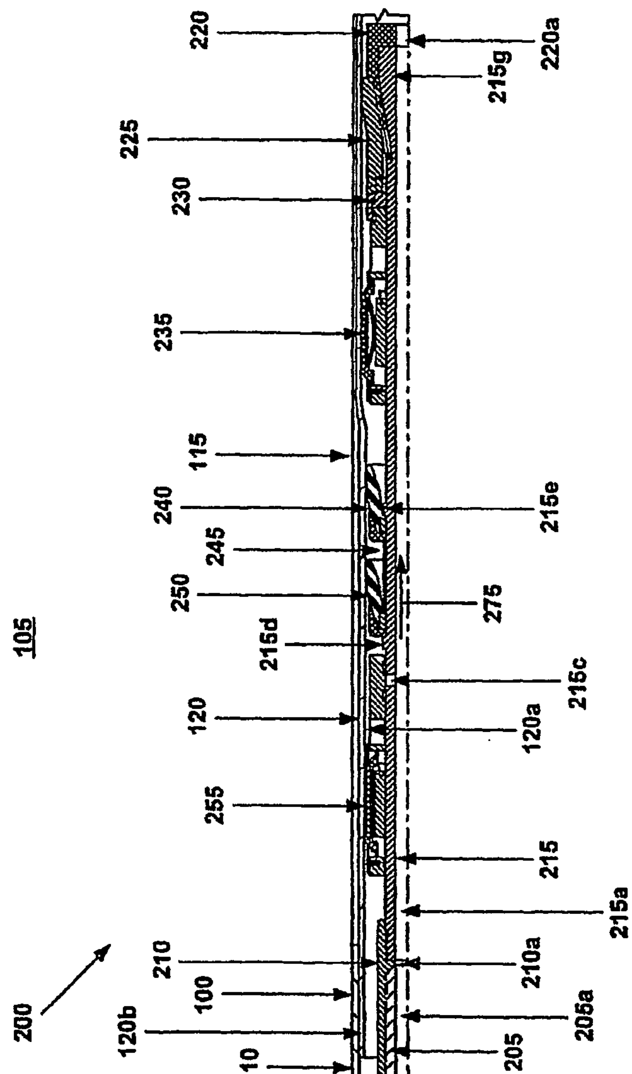
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Fig. 2

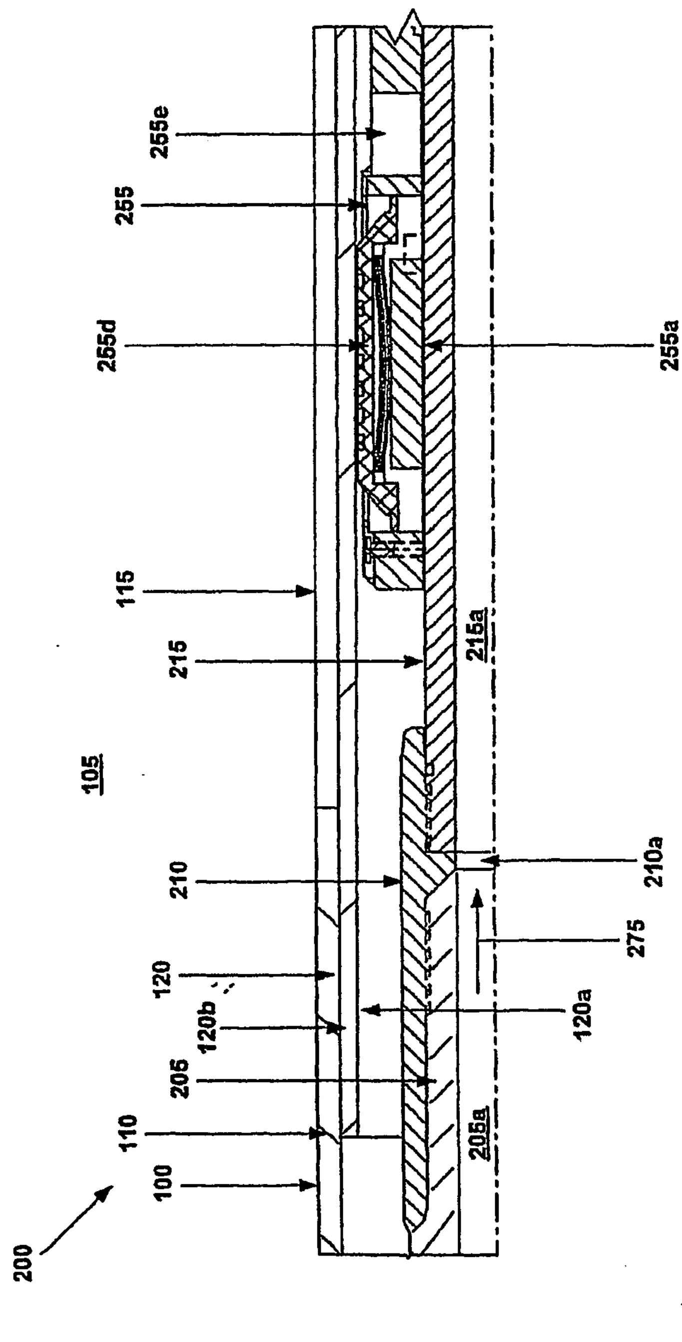
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Fig. 2a

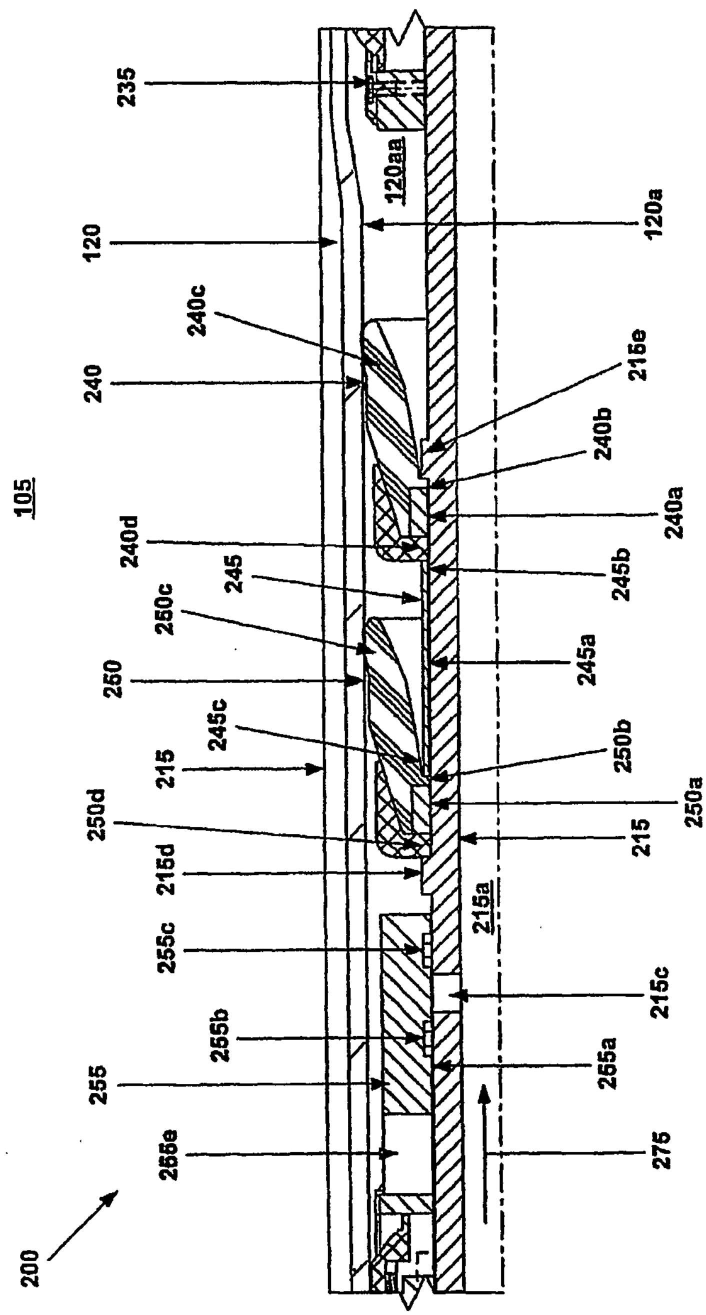
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Fig. 2b

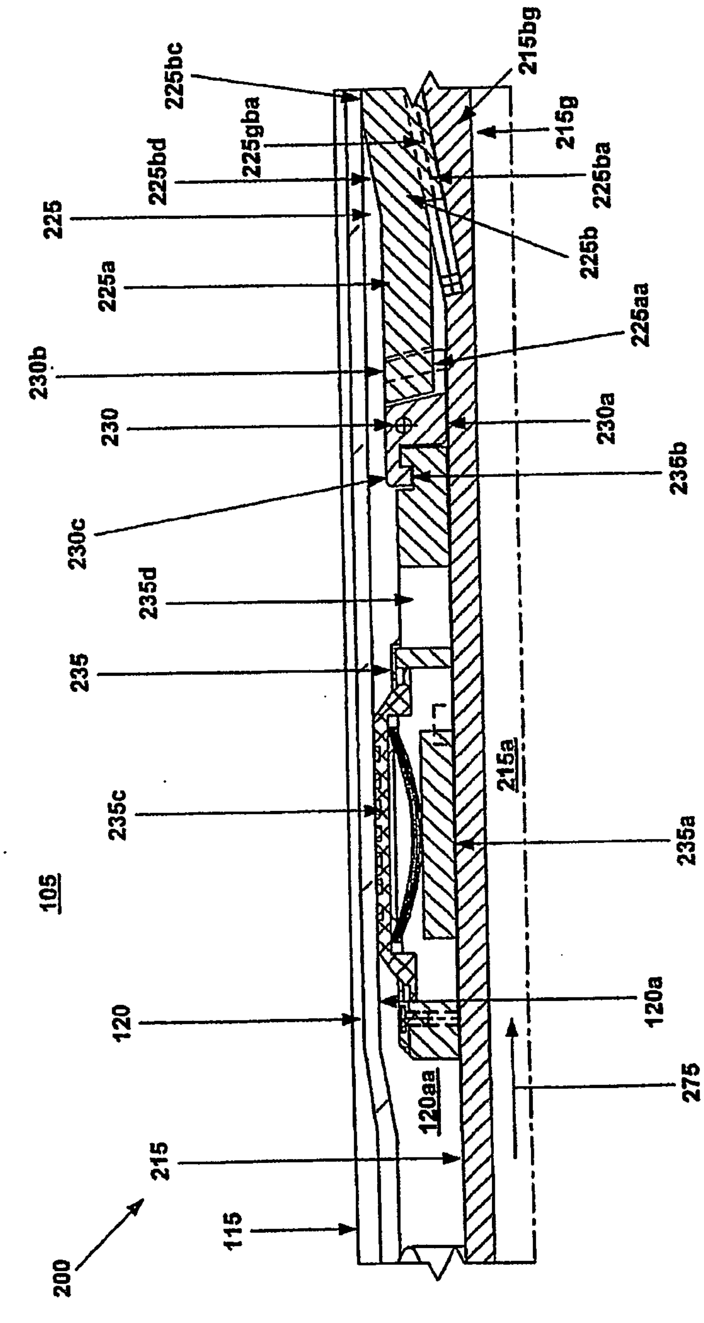
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Fig. 2c

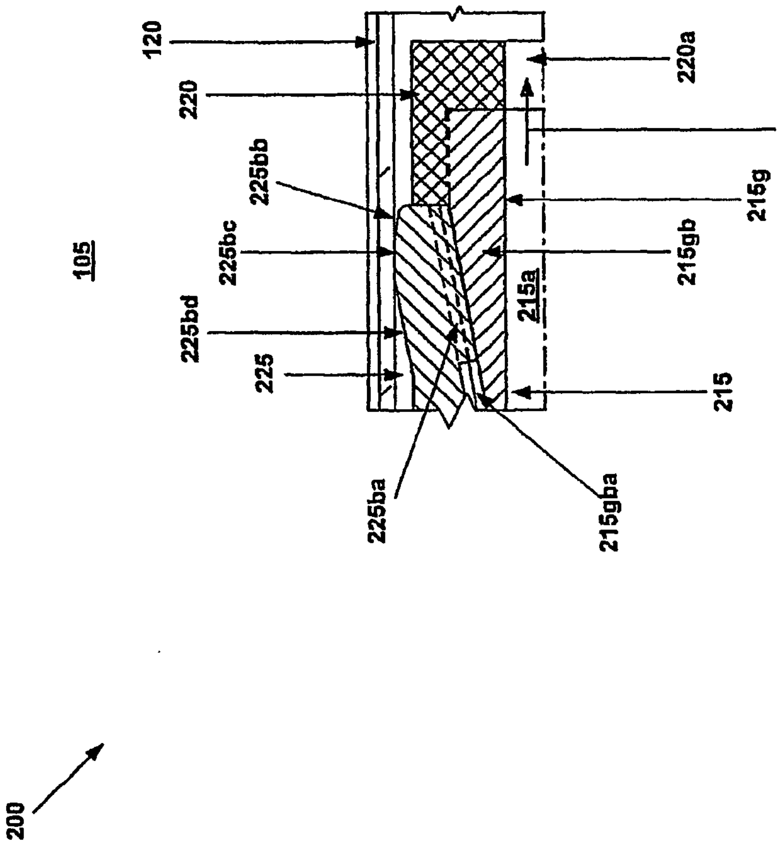
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Fig. 2d

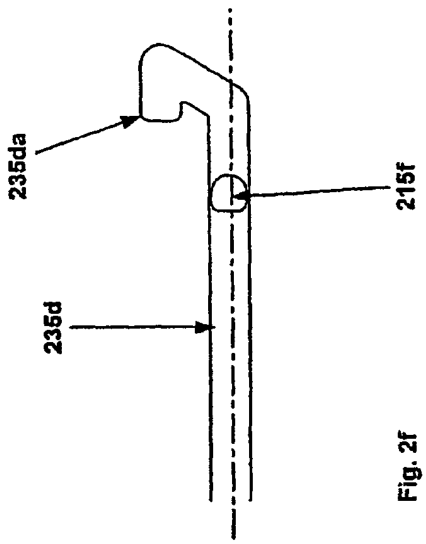


Fig. 2f

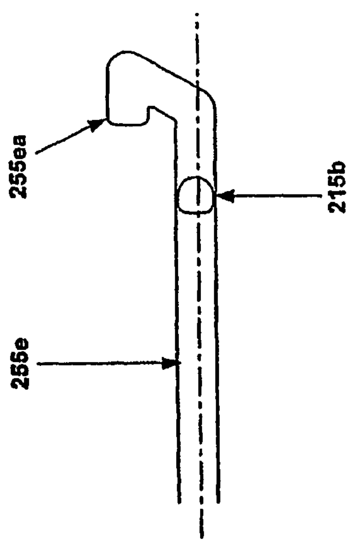


Fig. 2e

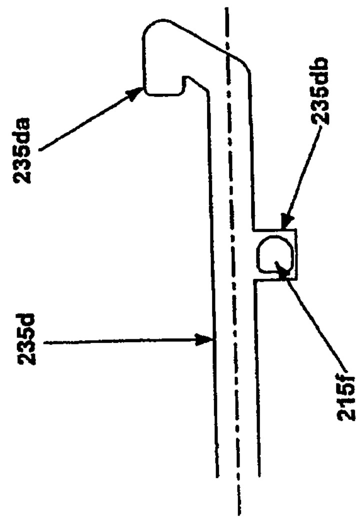


Fig. 2h

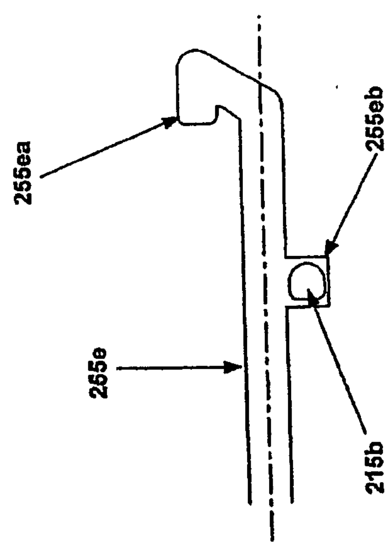


Fig. 2g

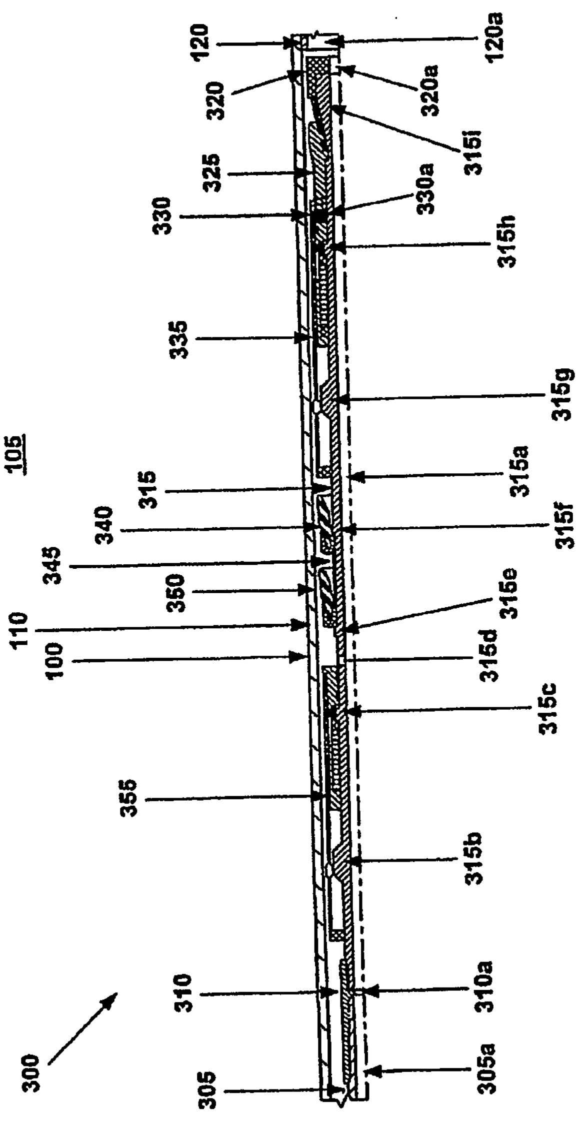
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Fig. 3

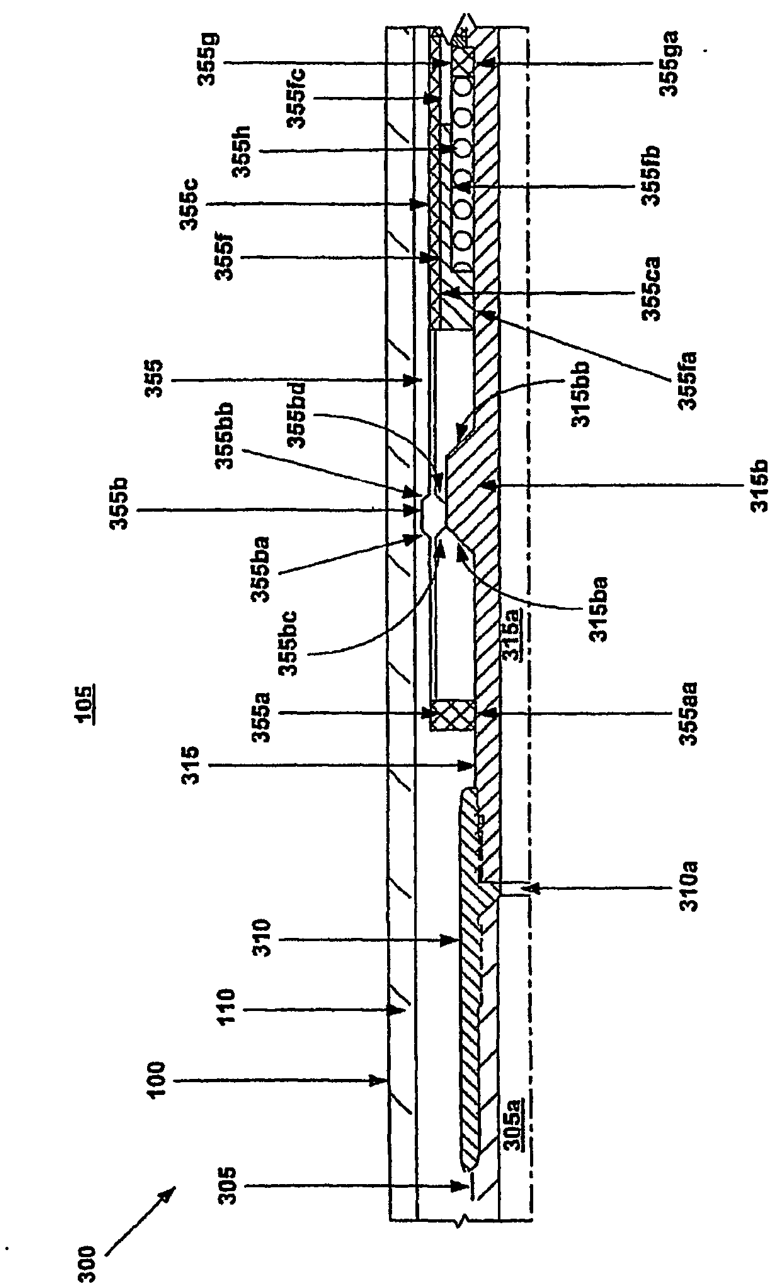
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Fig. 3a

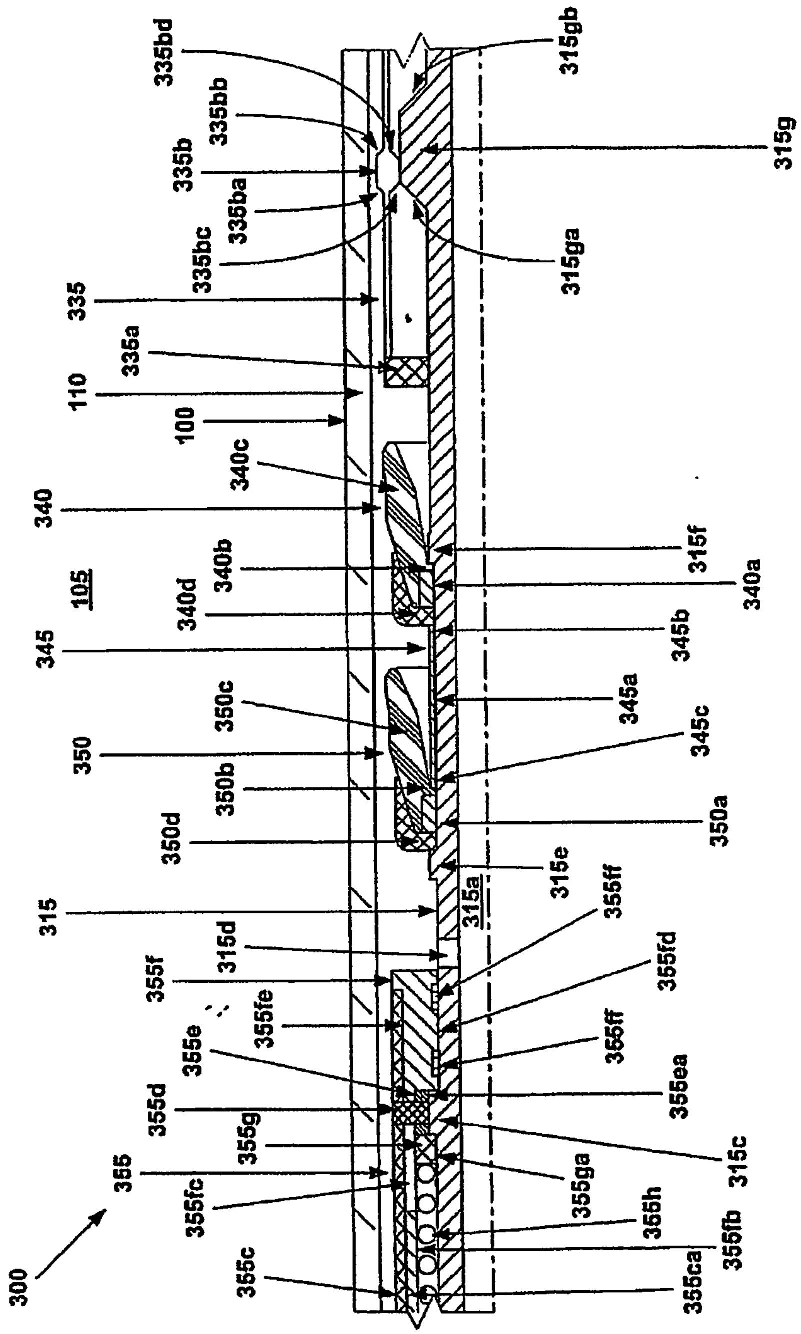

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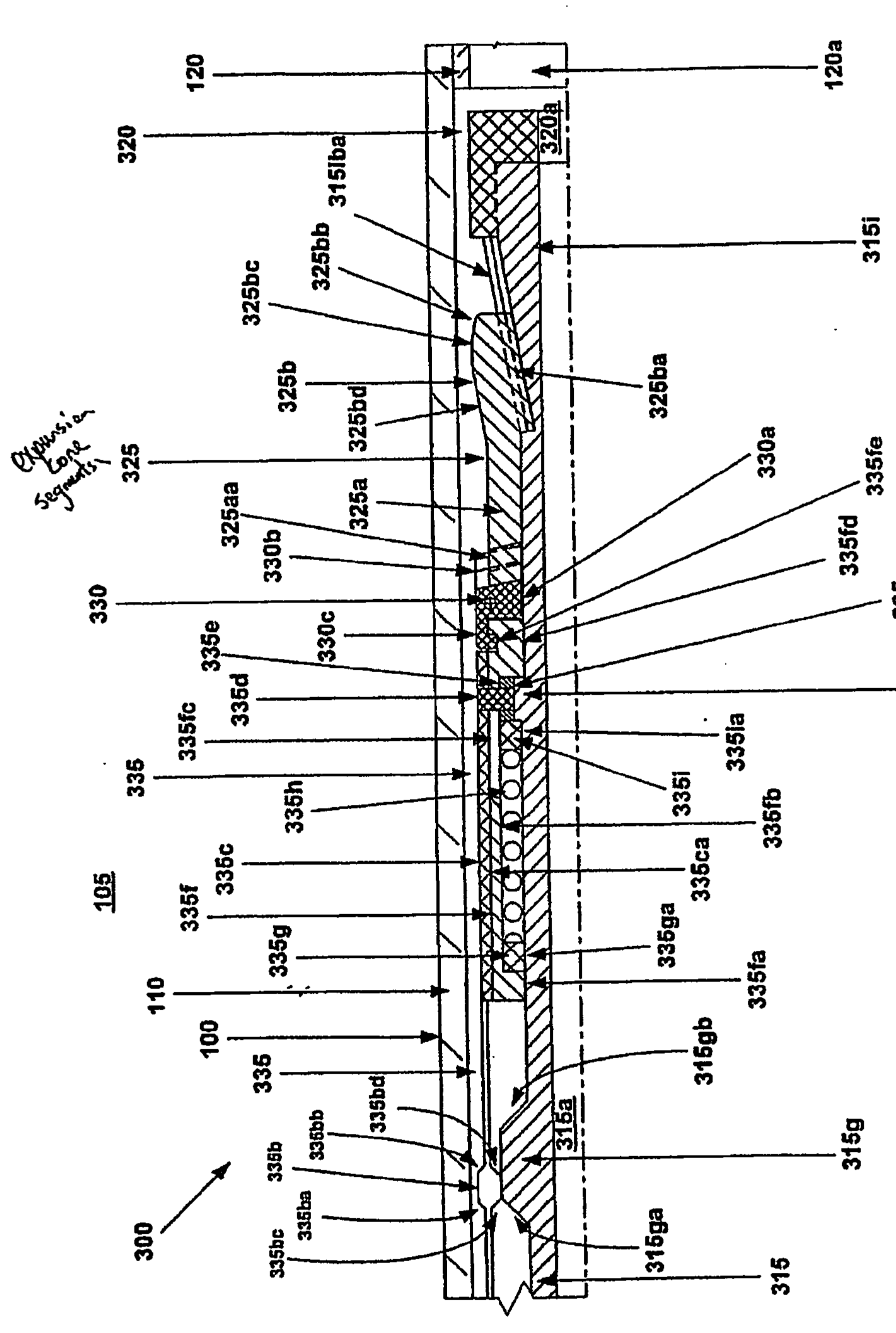
Fig. 3b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Expansion Cone Segments

Fig. 3c

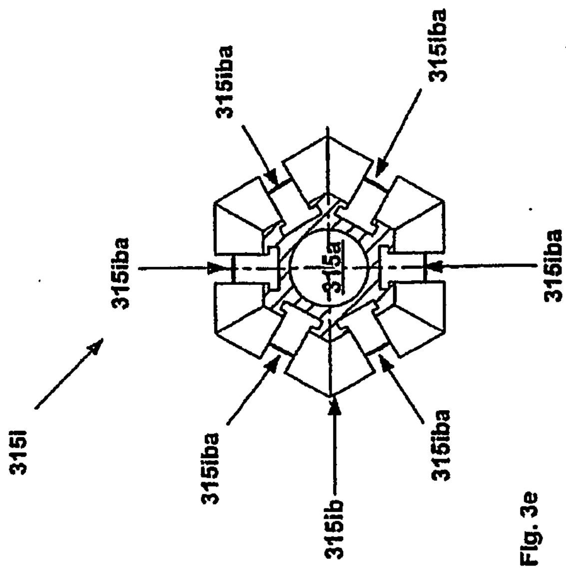
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Fig. 3e

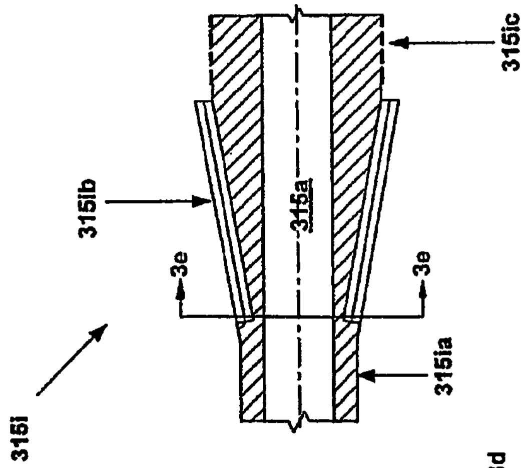
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Fig. 3d

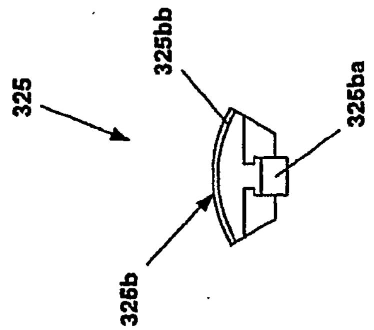



Fig. 3g

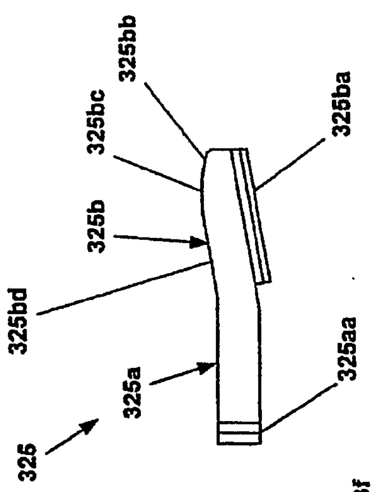



Fig. 3f

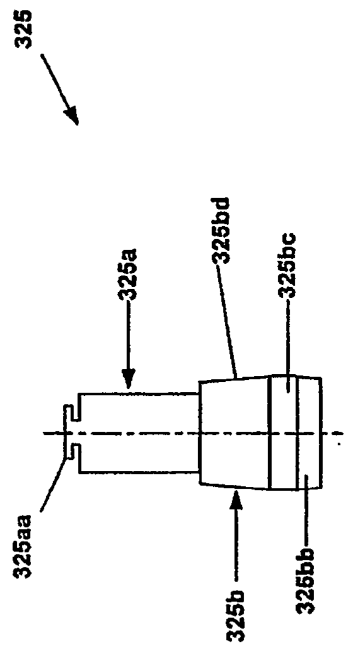
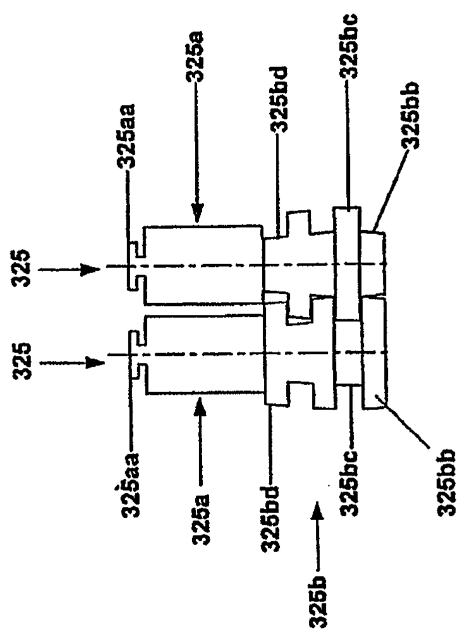



Fig. 3h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325aa
325a
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325bc
325bb
325aa
325a
325bd
325bc
325bb
325b

Fig. 3i

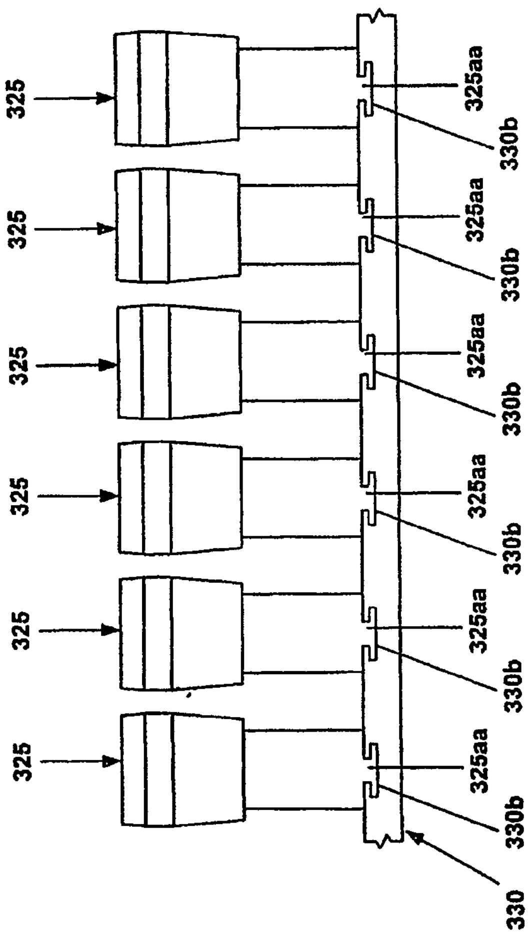
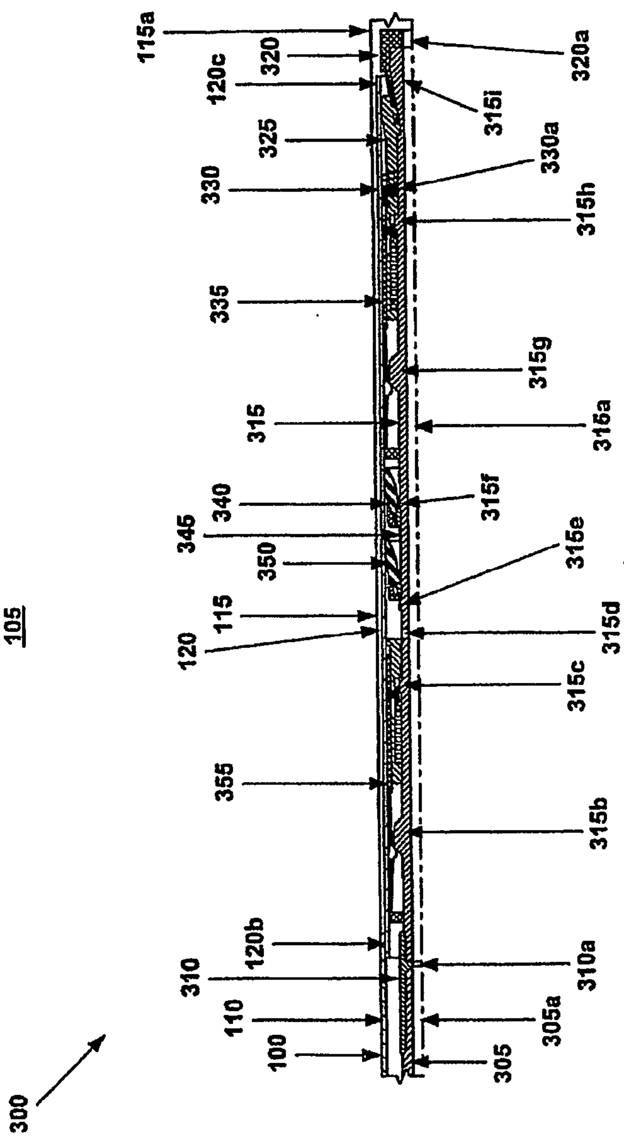

325
325
325
325
325
325
325aa
330b
325aa
330b
325aa
330b
325aa
330b
325aa
330b
325aa
330b
330

Fig. 3j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320
120c
325
330
335
315
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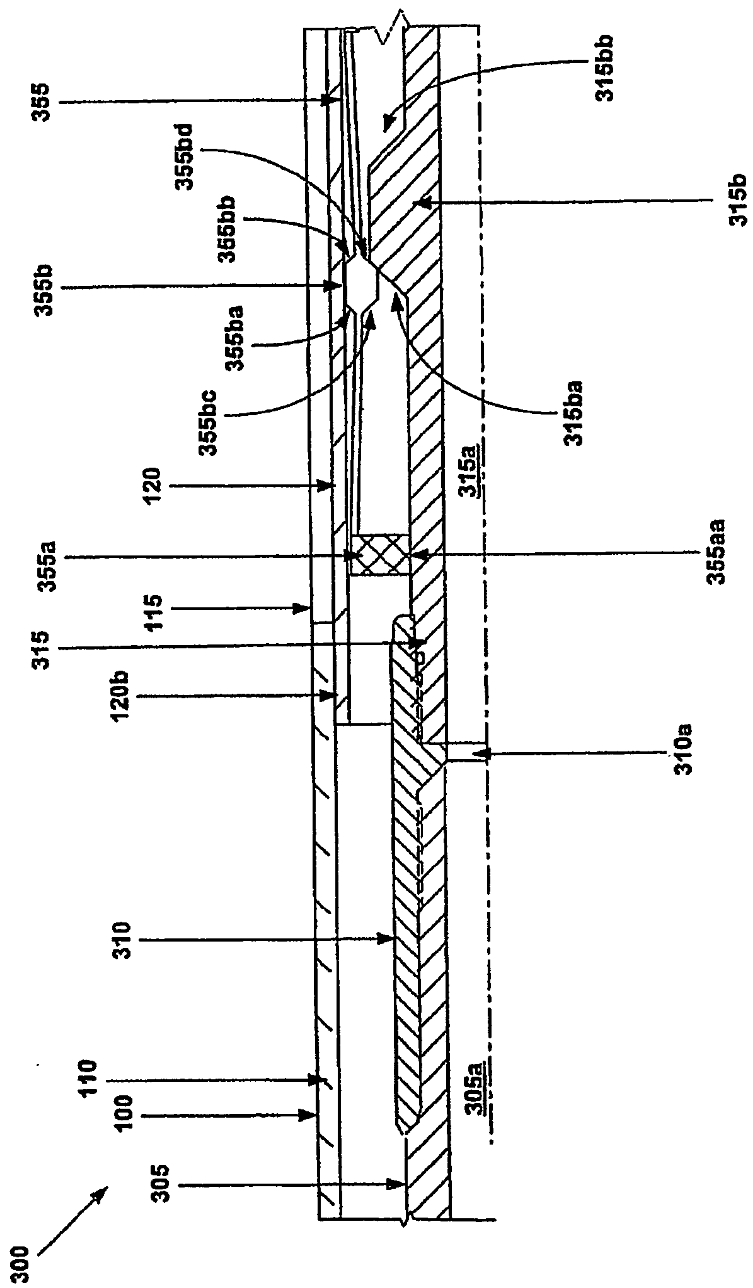
345
350
115
120
355
120b
310
110
100
300
105
320a
315i
330a
315h
315g
315a
315f
315e
315d
315c
315b
310a
305a
305

Fig. 4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310
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355bb
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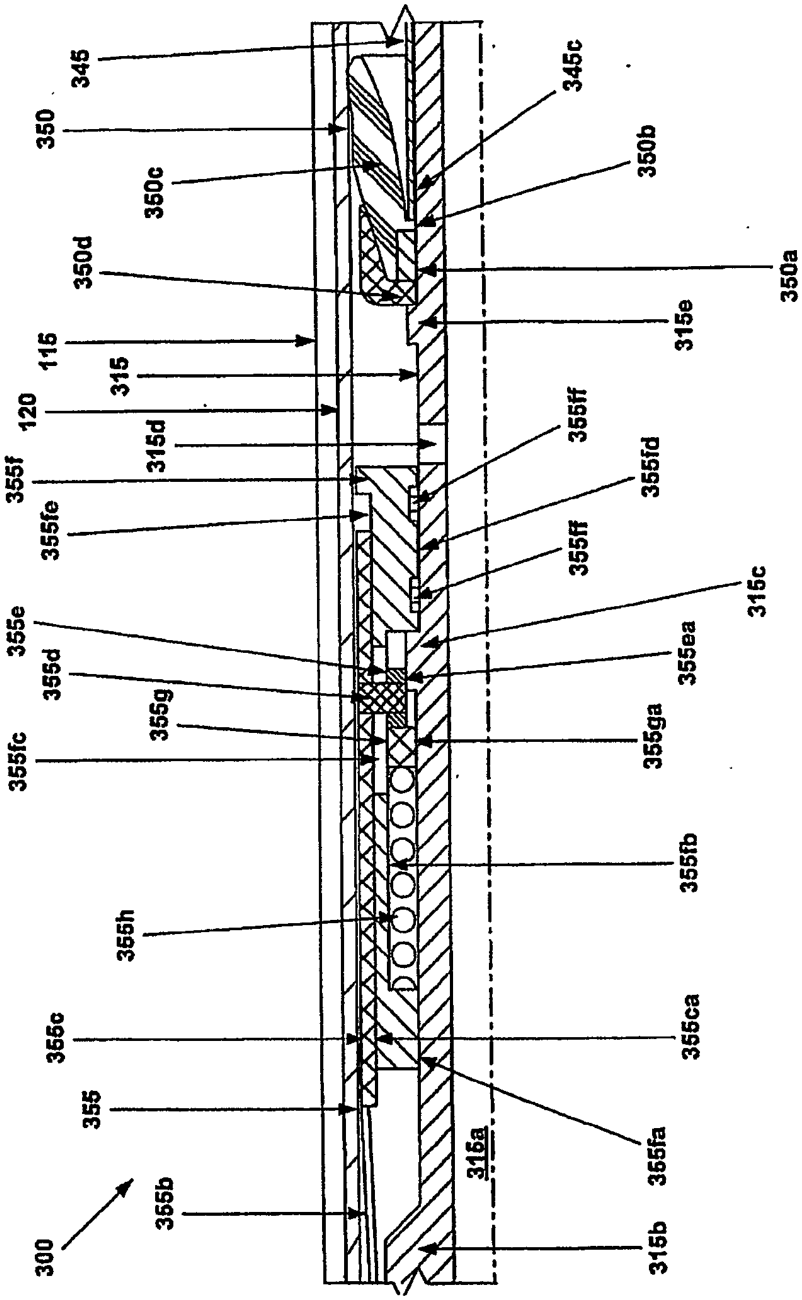
315bb
315b
315ba
315a
355aa
310a
305a

Fig. 4a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350d
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120
315d
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355e
355d
355g
355fc
355h
355c
355
355b
300
345c
350b
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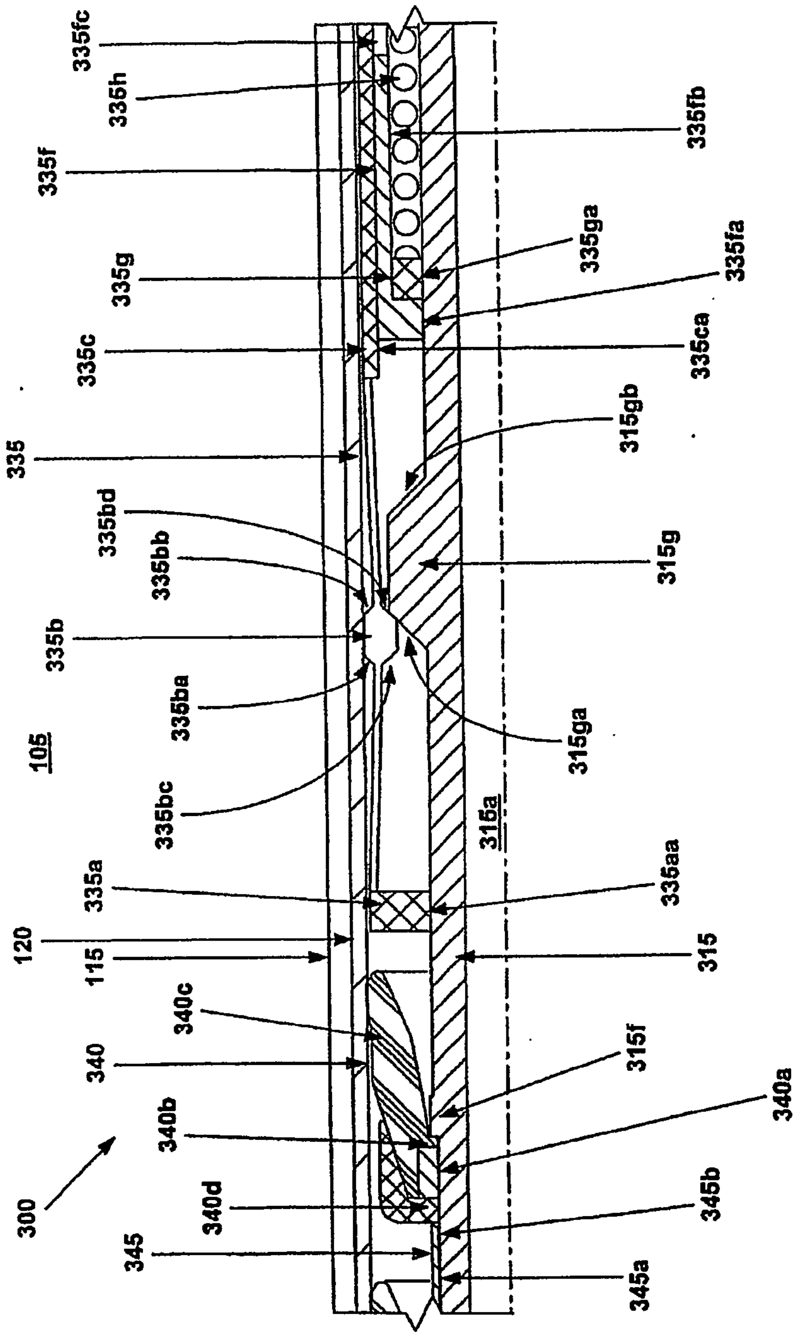
355fd
355ff
315c
355ea
355ga
355fb
355ca
355fa
315a
315b

Fig. 4b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345
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340
340c
115
120
335a
335bc
335ba
105
335b
335bb
335bd
335
335c
335g
335f
335h
335fc
335fb
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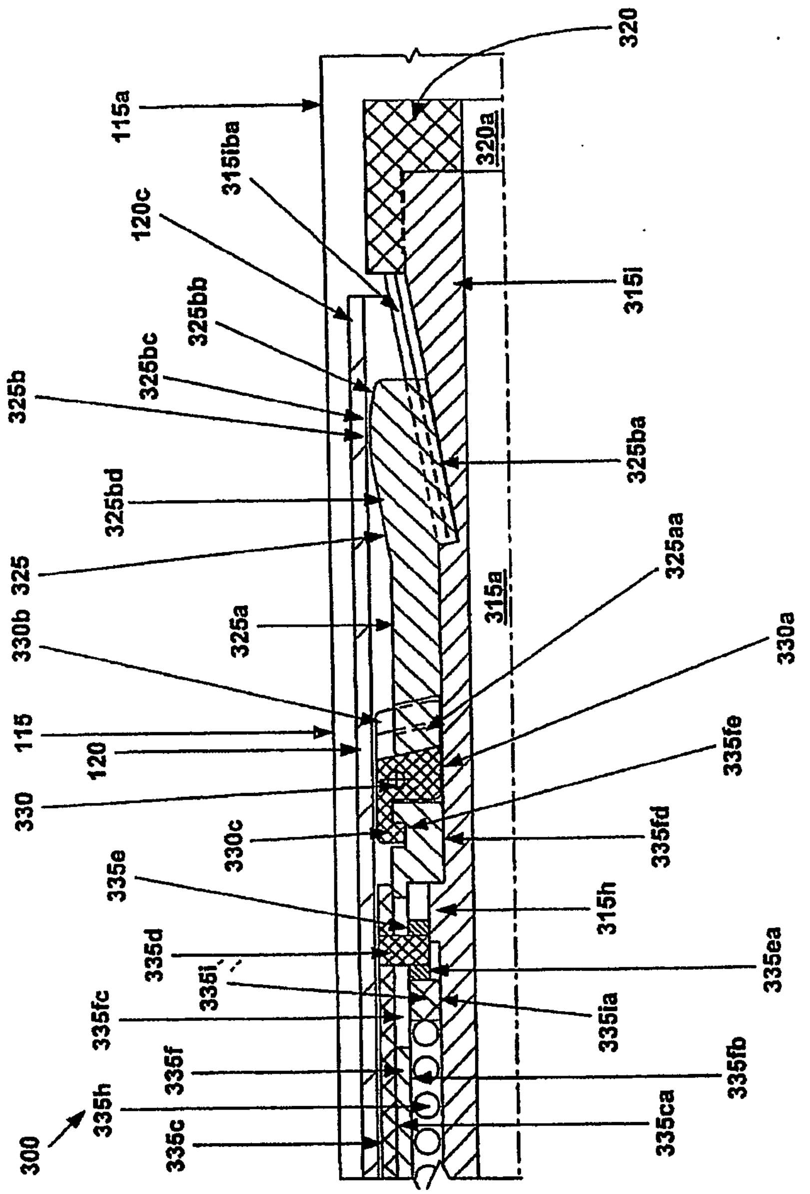
315gb
315g
315ga
315a
335aa
315
315f
340a
345b
345a

Fig. 4c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325b
325ba
325bd
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115
120
335fe
330
330c
335fd
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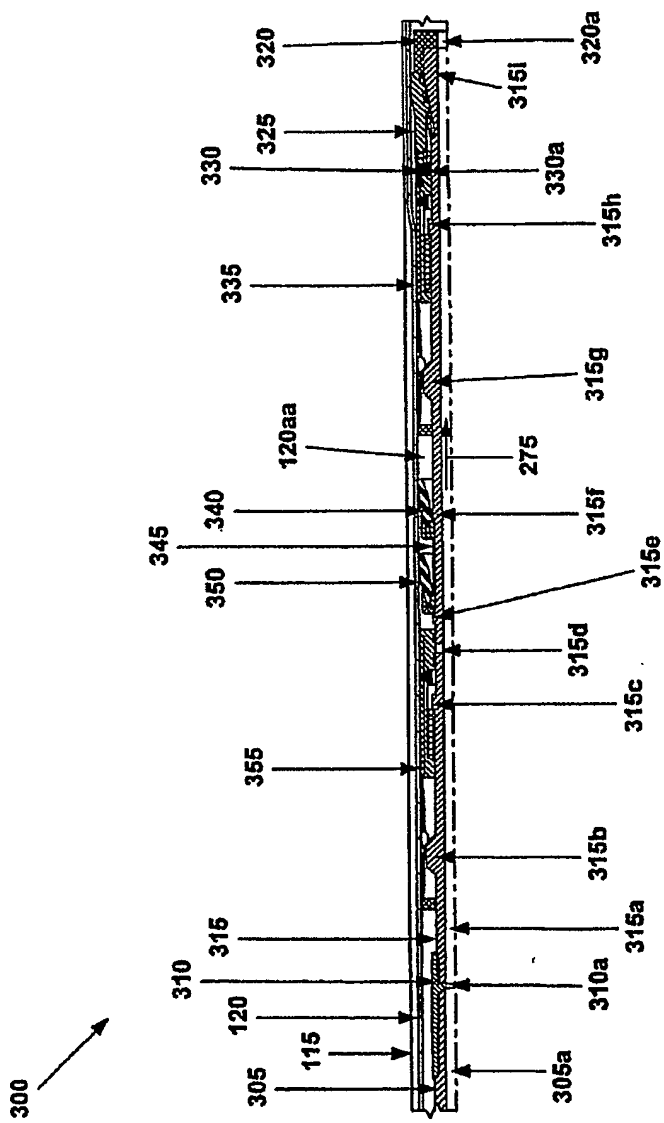
335i
335ea
335ia
335fc
335f
335fb
300
335h
335c
335ca

Fig. 4d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120aa
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330
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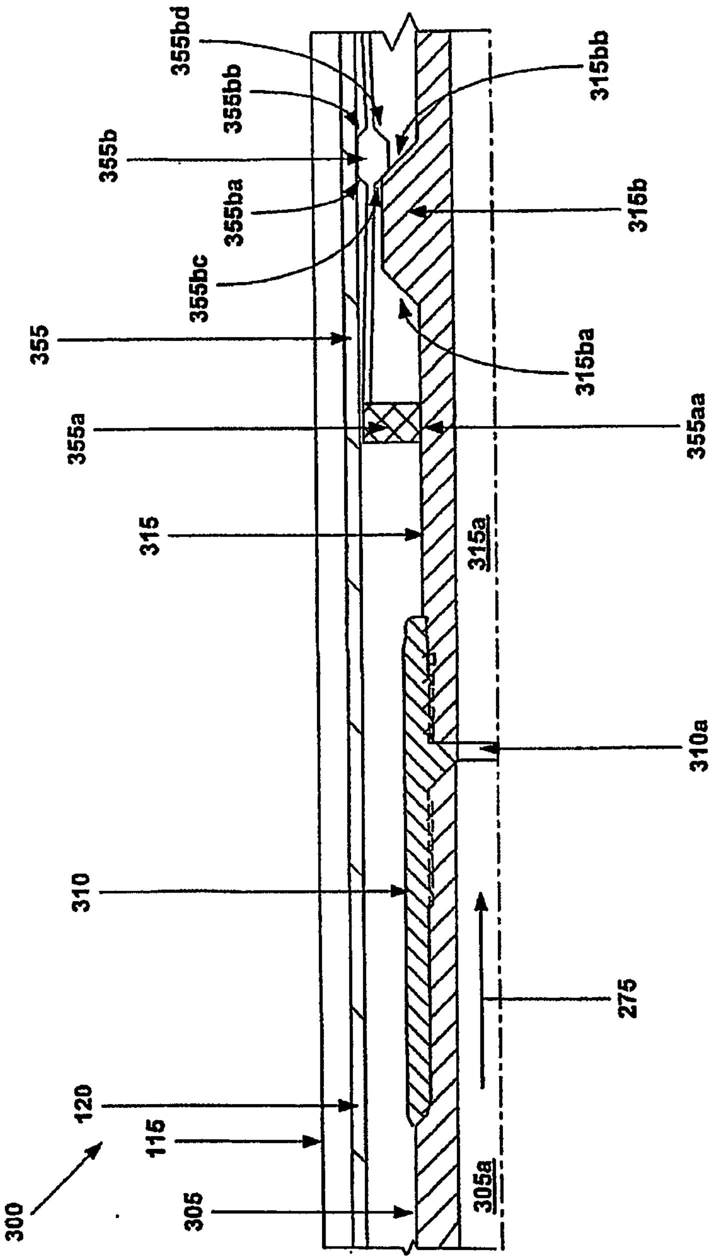
315b
315c
315d
315e
315f
275
315g
315h
330a
315i
320a

Fig. 5


355bd
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355ba
355bc
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355a
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115
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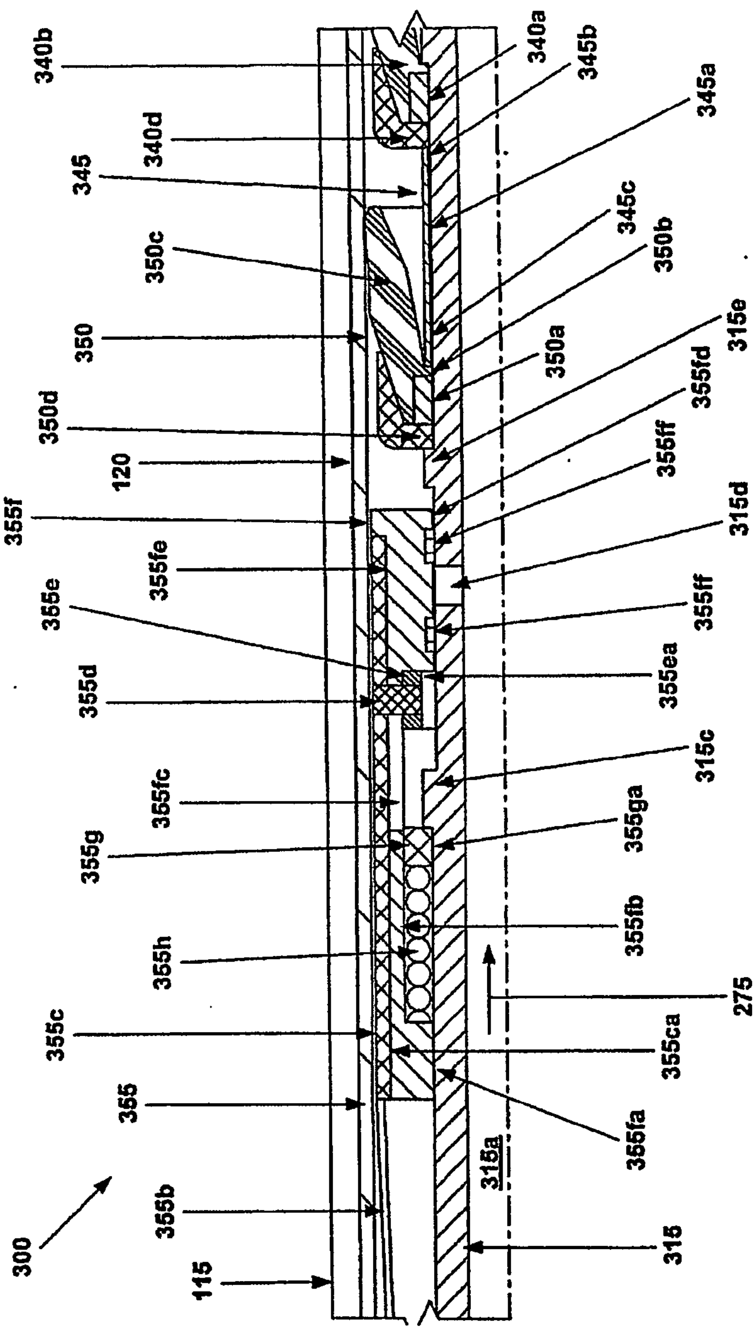
315bb
315b
315ba
355aa
315a
310a
275
305a

Fig. 5a



340b
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345b
340d
345a
345
345c
350c
350b
350
350a
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350d
355fd
120
355ff
355f
315d
355fe
355ff
355e
355ea
355d
315c
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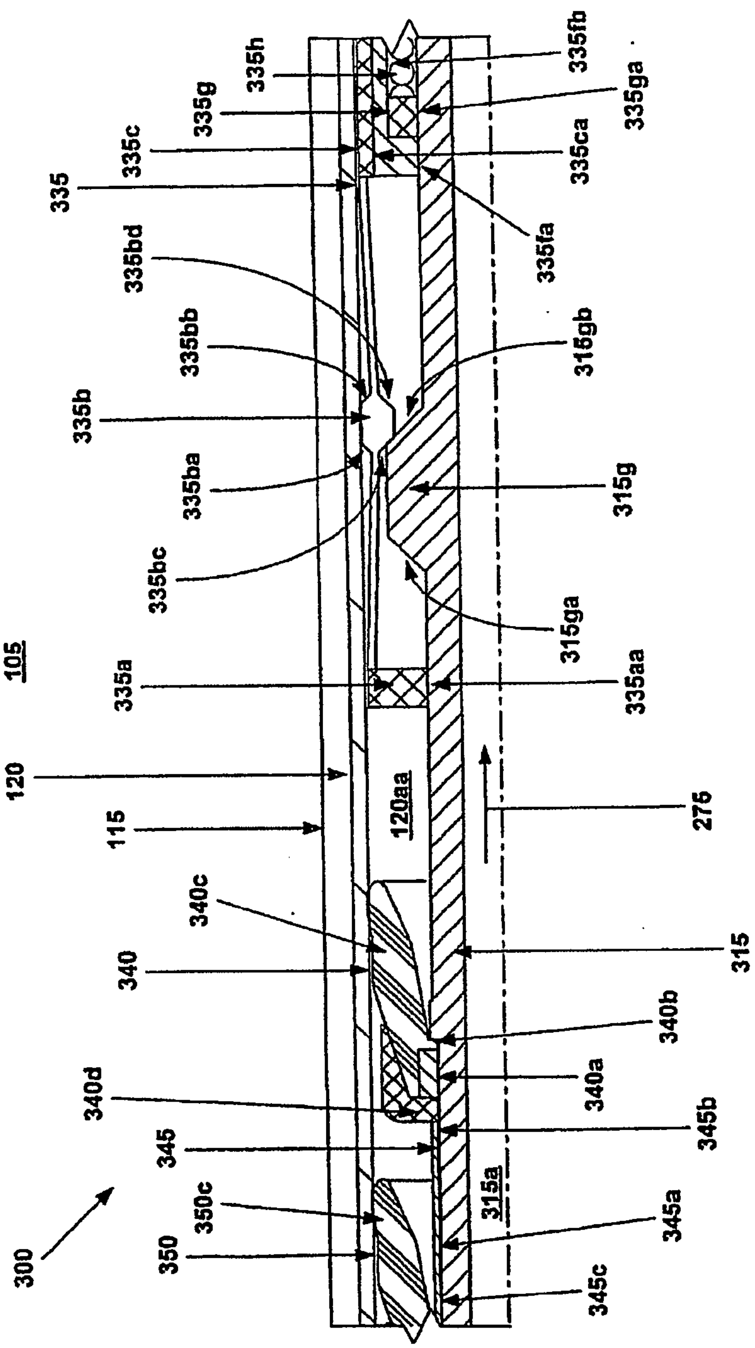
355fb
355h
275
355c
355ca
365
355fa
315a
300
355b
315
115


Fig. 5b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350c
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340d
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340c
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120
120aa
105
335a
335bc
335ba
335b
335bb
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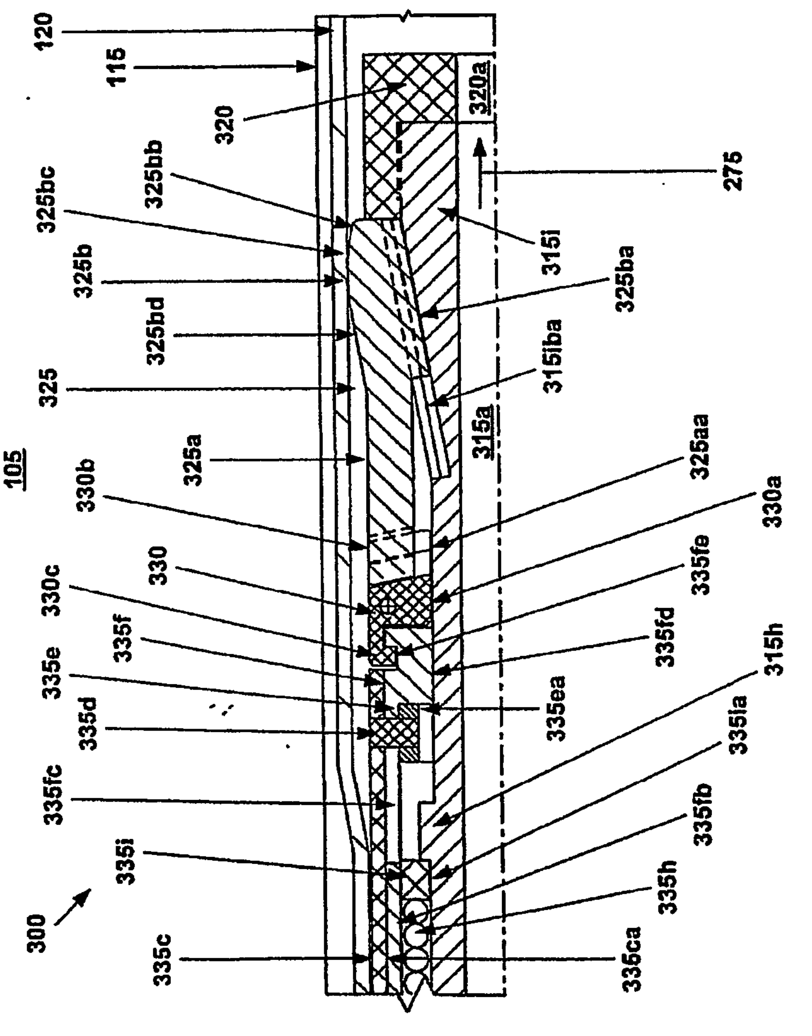
335c
335g
335h
335fb
335ga
335ca
335fa
315gb
315g
315ga
335aa
276
315
340b
340a
345b
345a
345c
315a

Fig. 5c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315i
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325bd
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325
315a
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330a
330
335fe
330c
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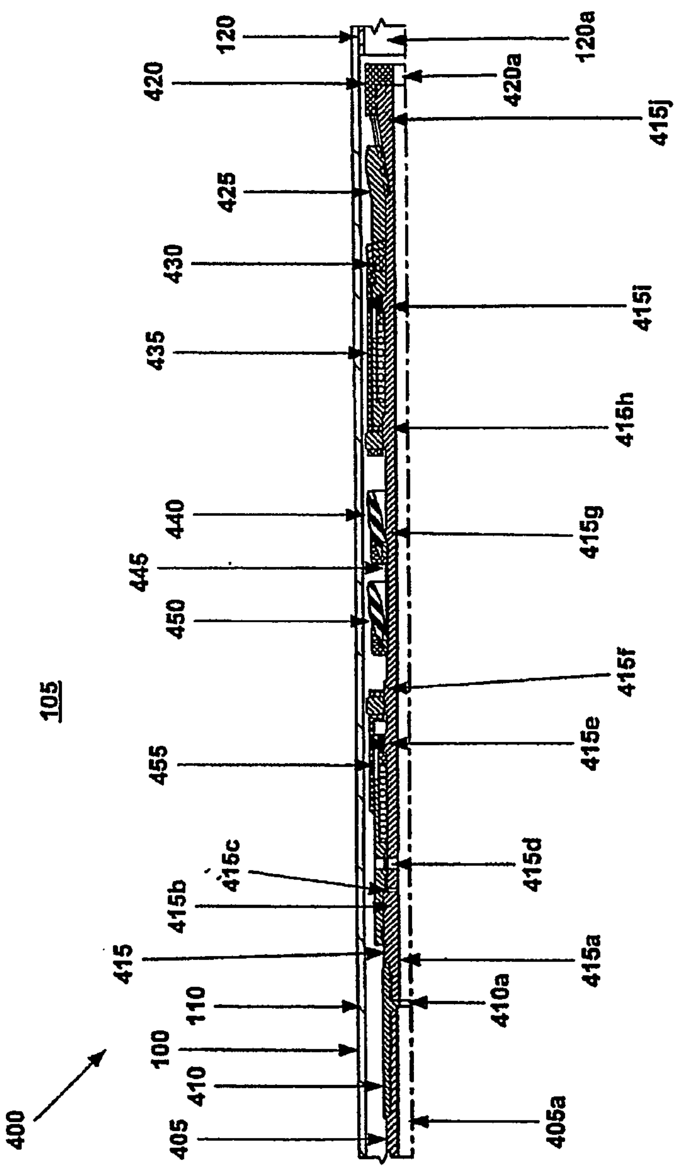
335h
300
335c
335ca

Fig. 5d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445
440
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430
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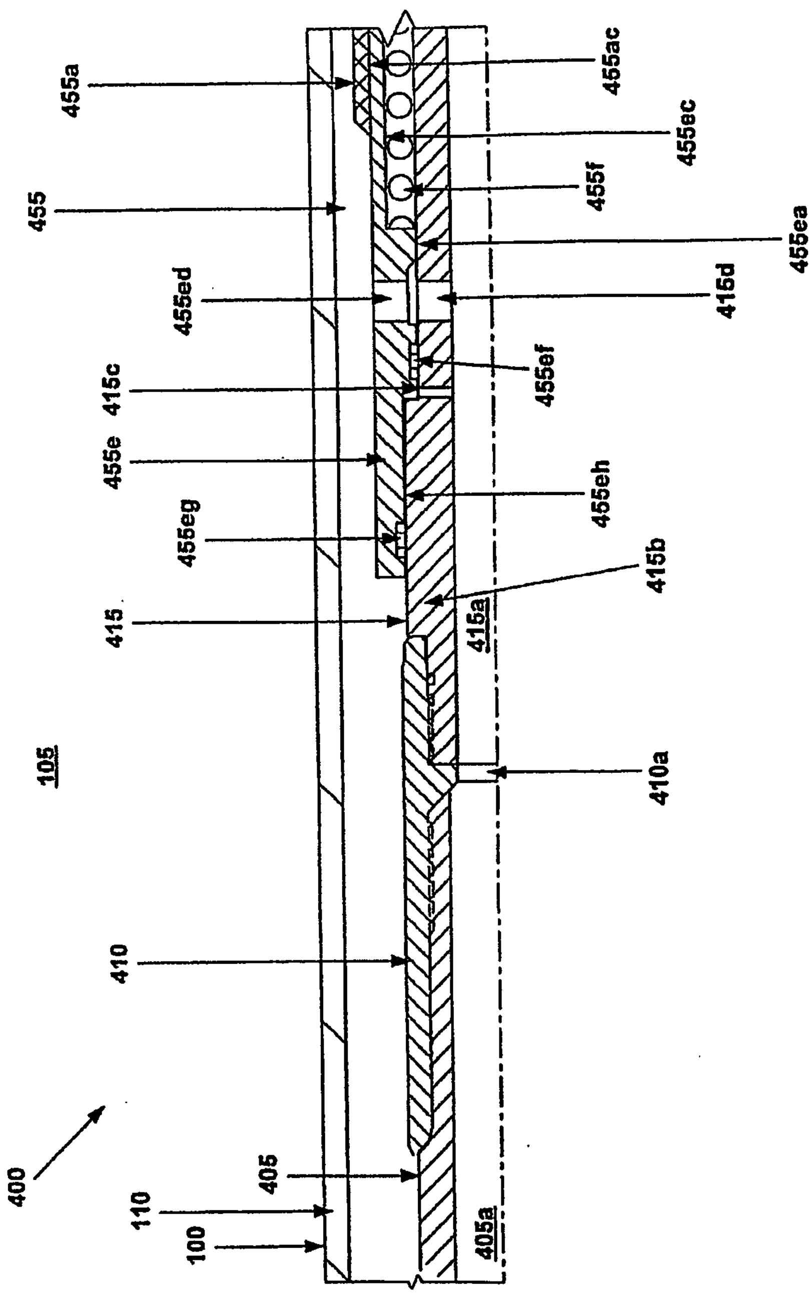
420a
415j
415i
415h
415g
415f
415e
415d
415a
410a
405a

Fig. 6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455ed
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415b
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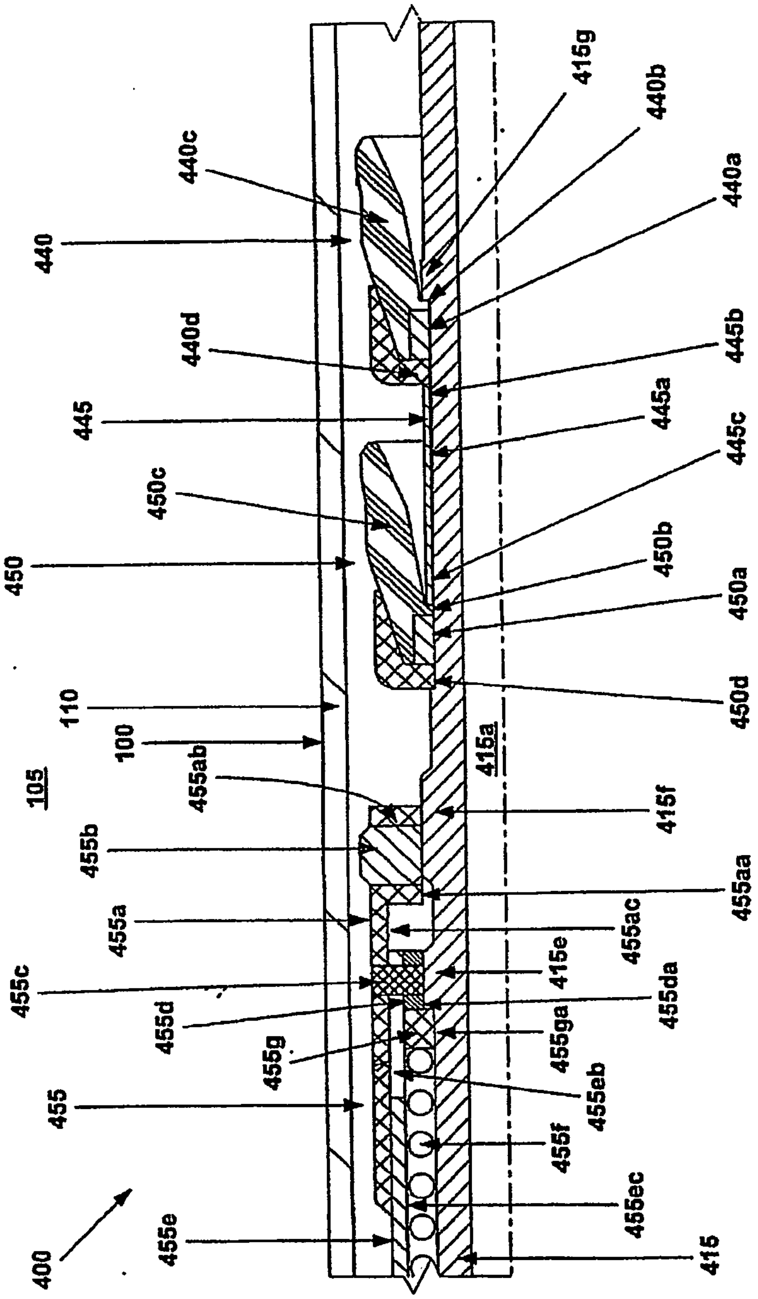
415a
105
410a
410
400
405
110
100
405a

Fig. 6a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455b
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450
450c
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440d
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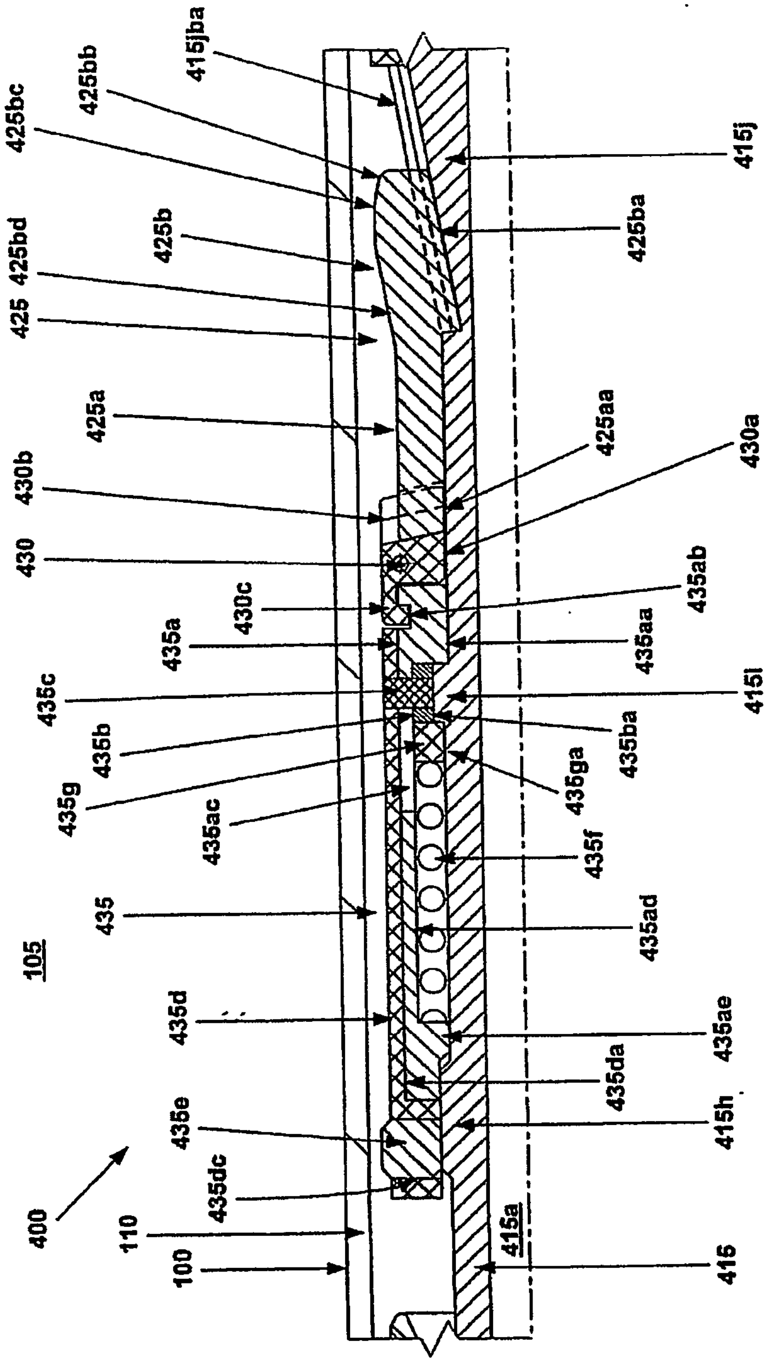
440c
415g
440b
440a
445b
445a
445c
450b
450a
450d
415a
415f
455aa
455ac
415e
455da
455ga
455eb
455f
455ec
415

Fig. 6b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415j
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425ba
425bd
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425a
425aa
430a
430b
430
430c
435ab
435a
435aa
435c
415l
435b
435ba
435g
435ga
435ac
435f
435
435ad
105
435d
435ae
435da
435e
415h
400
435dc
110
415a
100
415

Fig. 6c

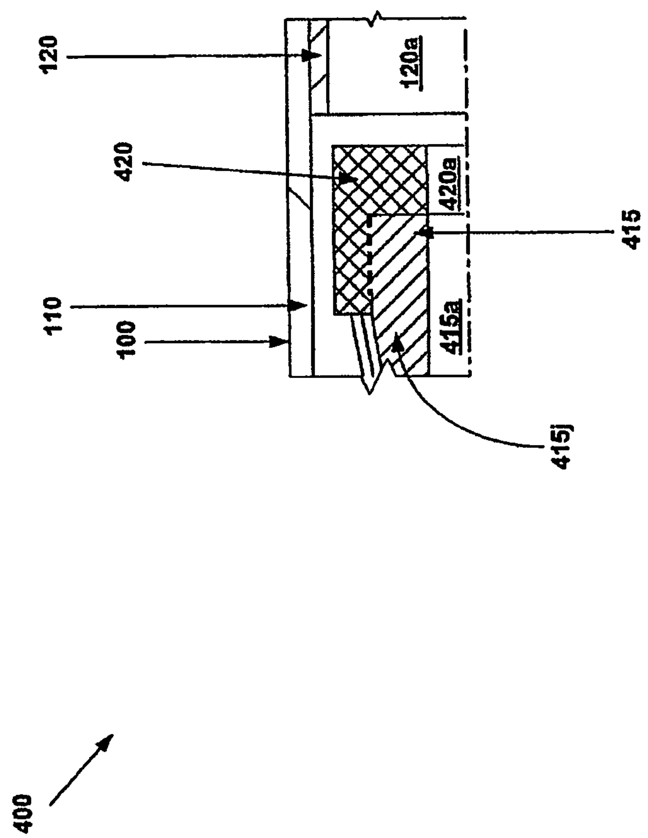
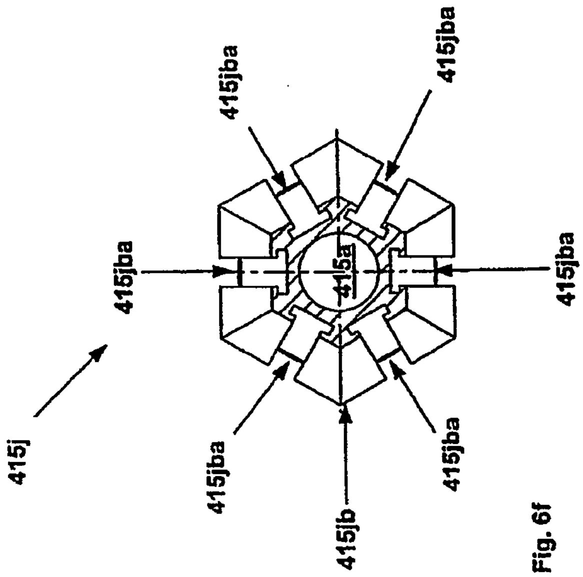



Fig. 6d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415jba
415jba
415jba
415jba
415jba
415a
415jb

Fig. 6f

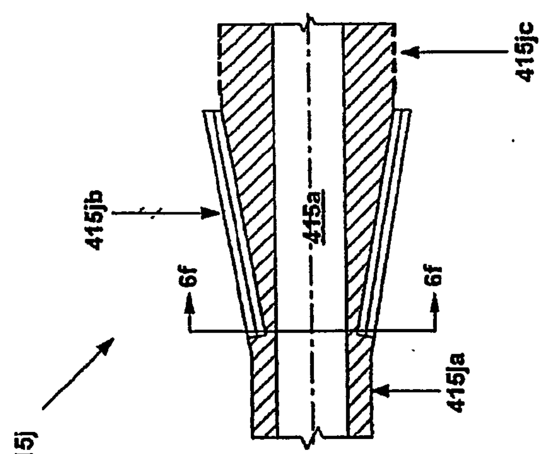

415j
415jb
415a
6f
6f
415ja
415jc

Fig. 6e

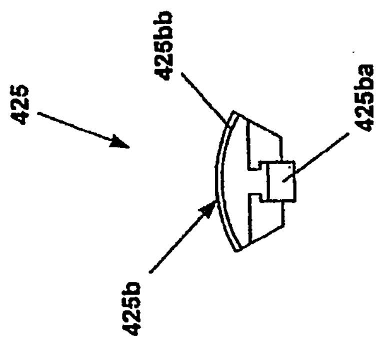



Fig. 6h

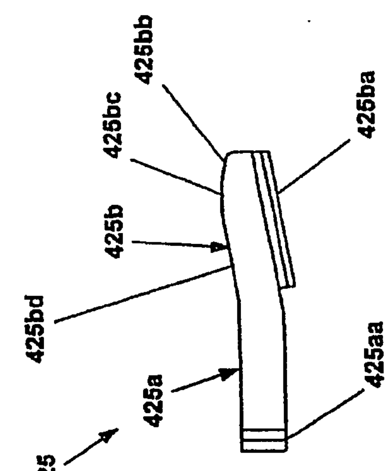



Fig. 6g

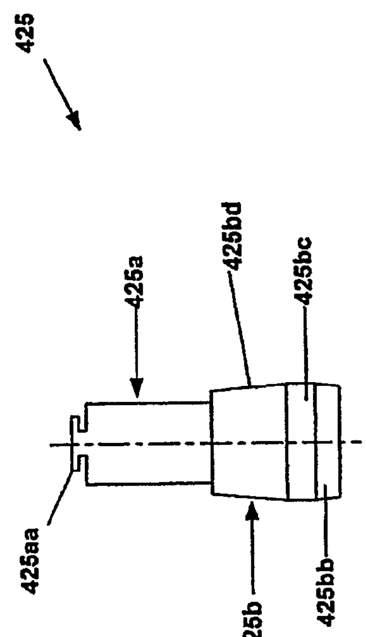
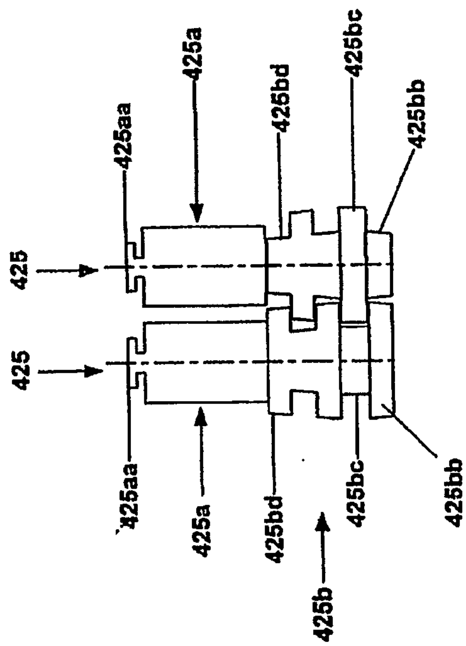



Fig. 6i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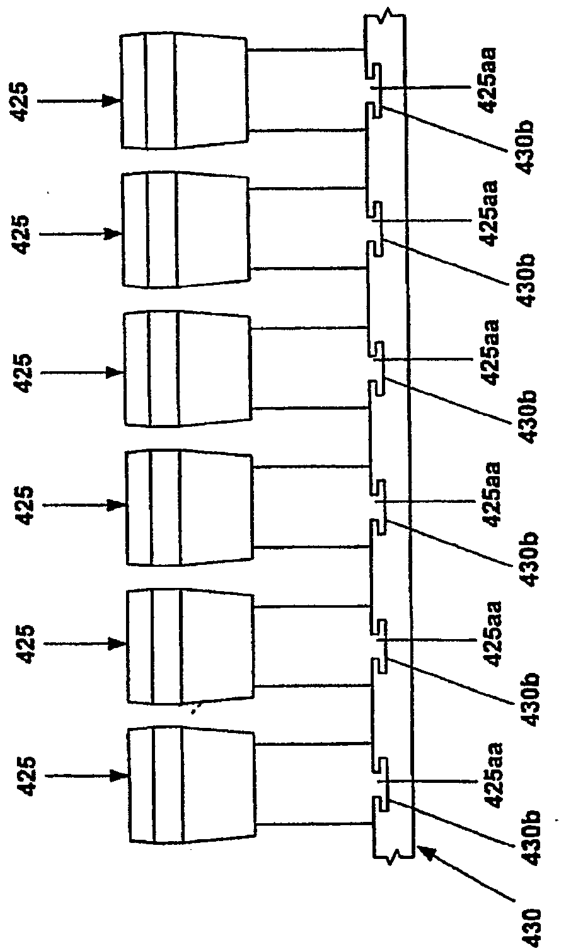
425bc
425bb
425b

Fig. 6j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425
425
425
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425aa
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425aa
430b
425aa
430b
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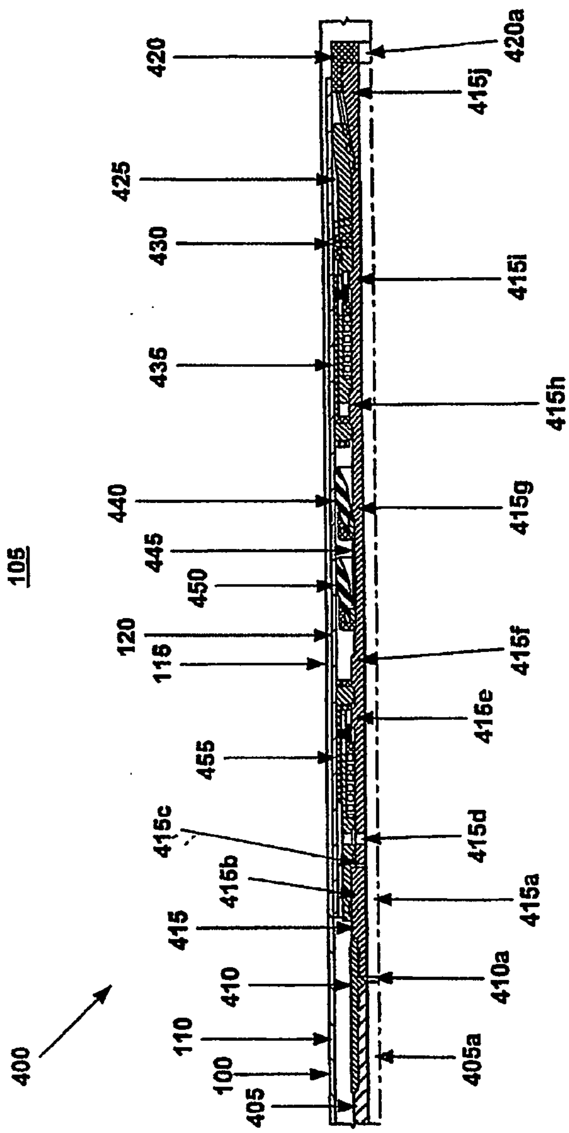
430b
425aa
430b
425aa
430b
430

Fig. 6k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400
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415j
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415i
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415h
440
415g
445
450
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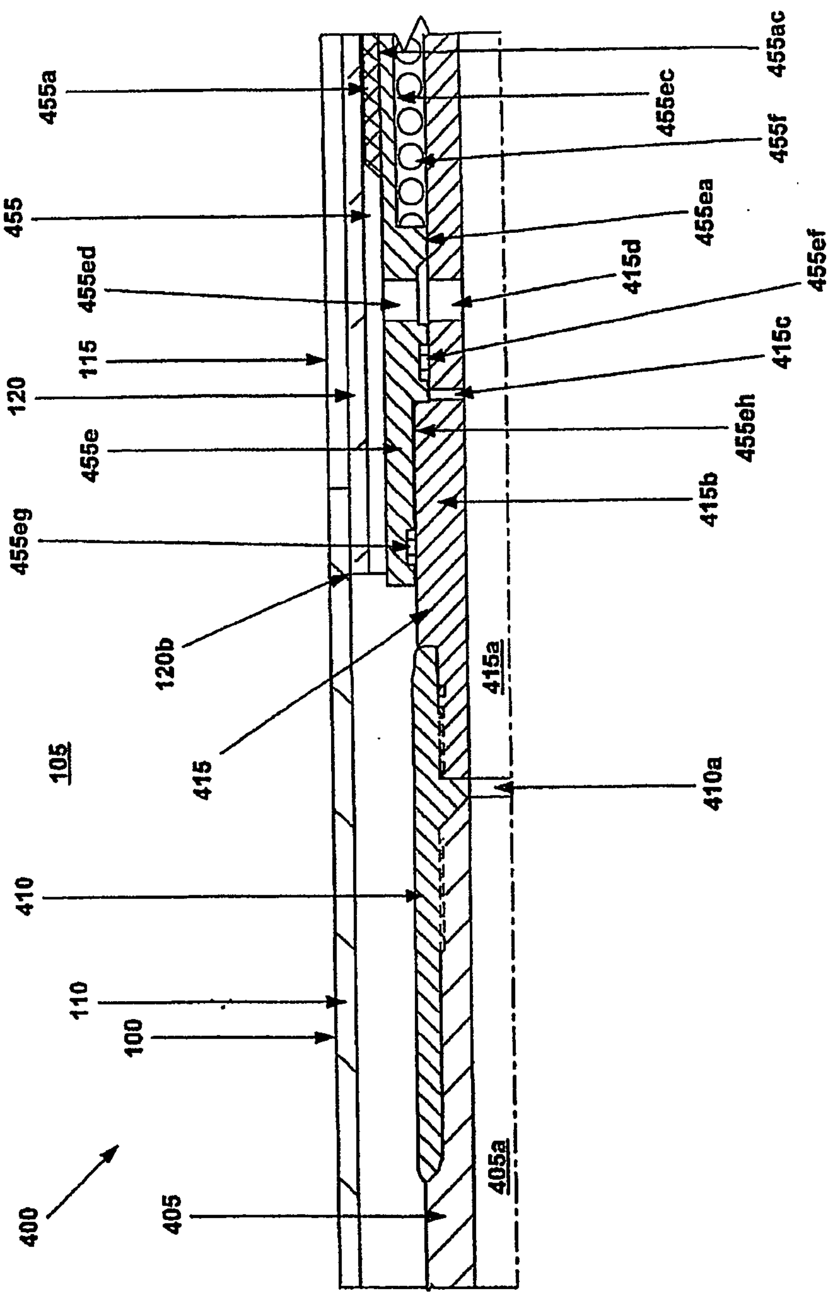
415c
415d
415b
415a
415
410
410a
110
100
405
405a

Fig. 7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455ed
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415a
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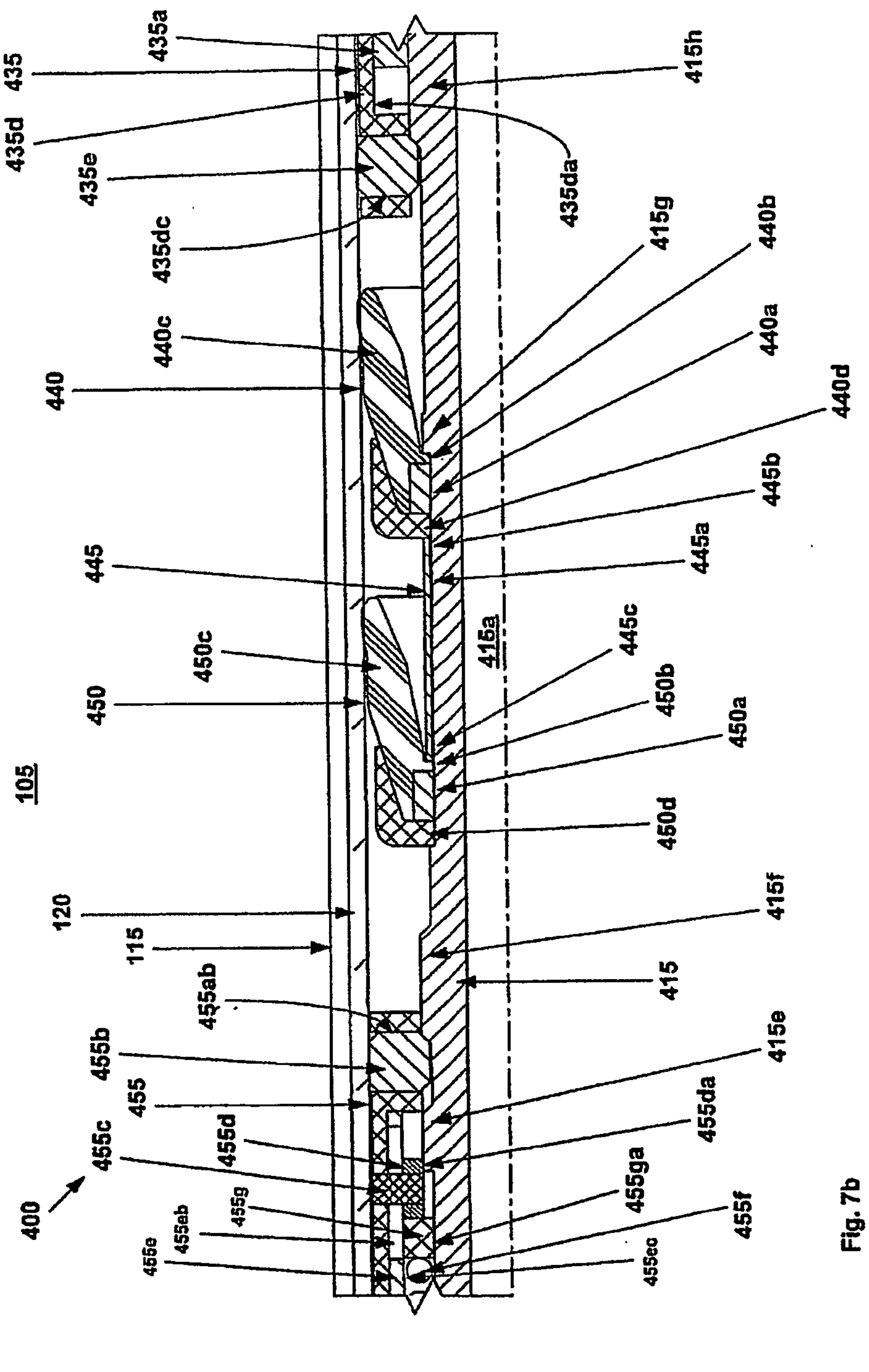
105
410a
410
110
100
405a
400
405

Fig. 7a



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415g
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450c
415a
450
450b
450a
105
450d
120
415f
115
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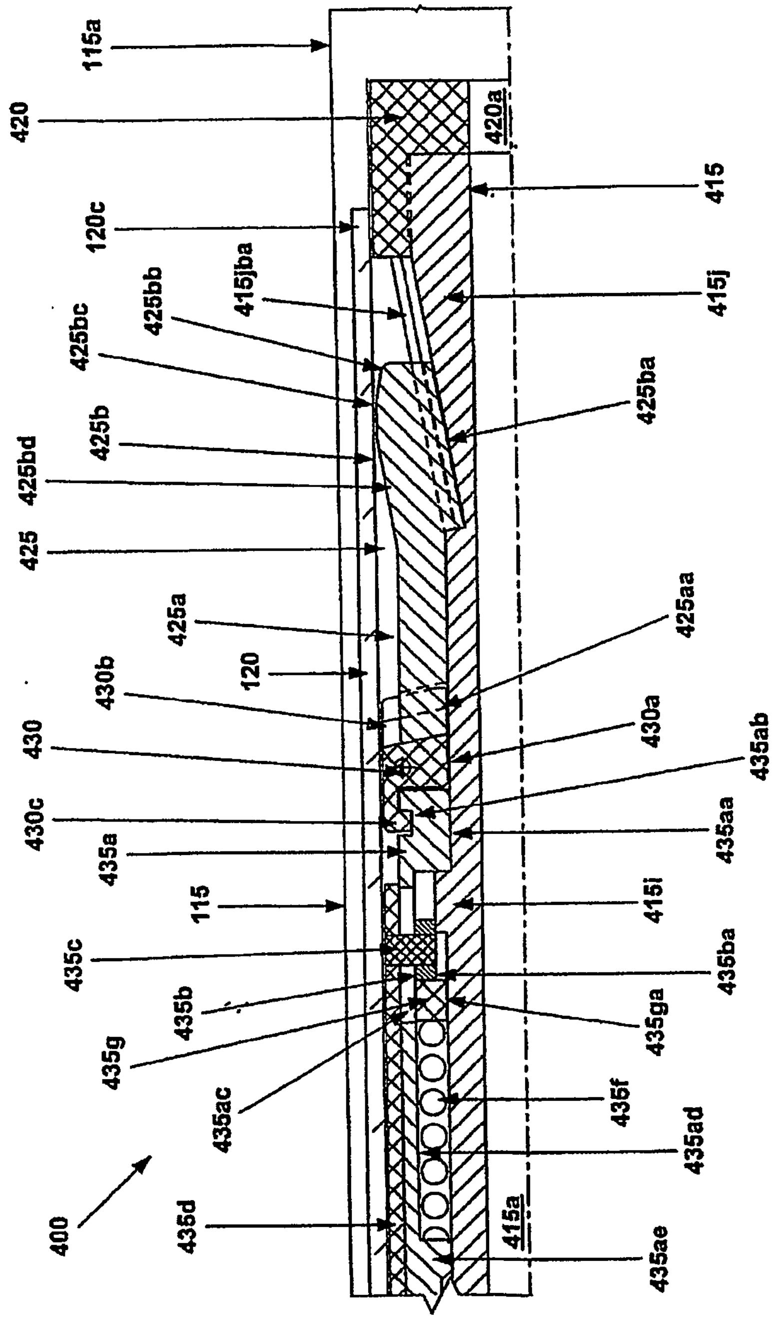
455g
455eb
455e
455f
455ec


Fig. 7b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415j
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425a
425aa
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430b
430a
430
435ab
430c
435aa
435a
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435g
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435f
435ad
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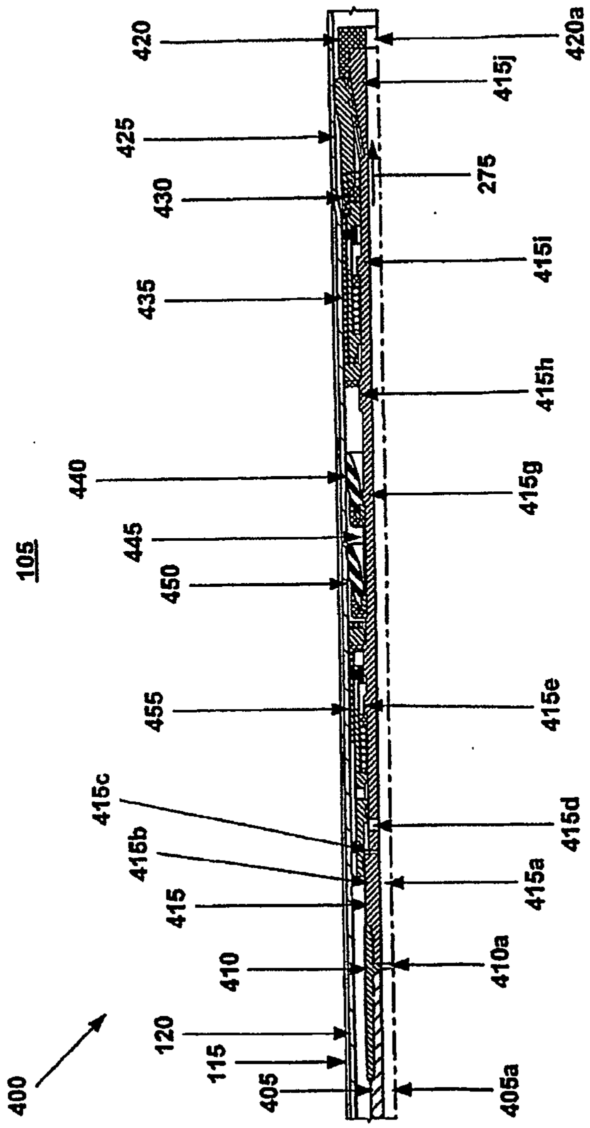
435d
415a
435ae

Fig. 7c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415c
415b
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415g
415e
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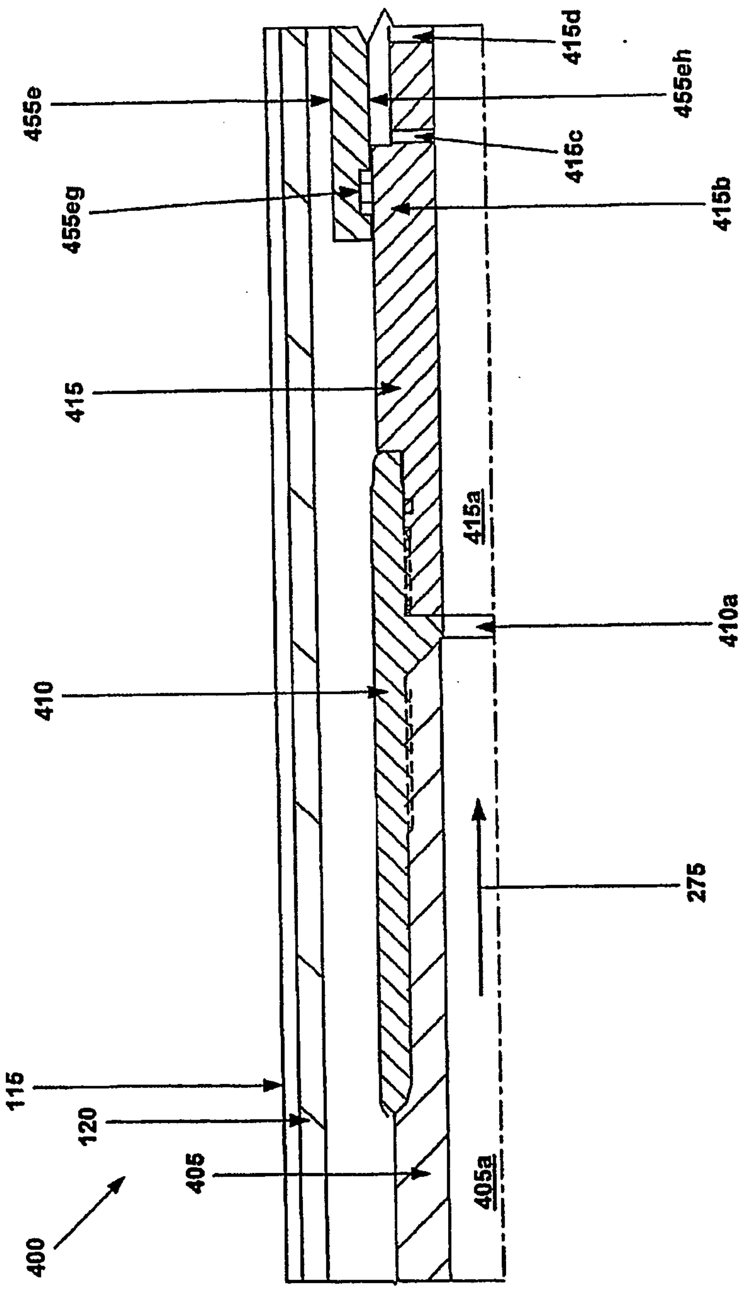
415a
410a
405a

Fig. 8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275
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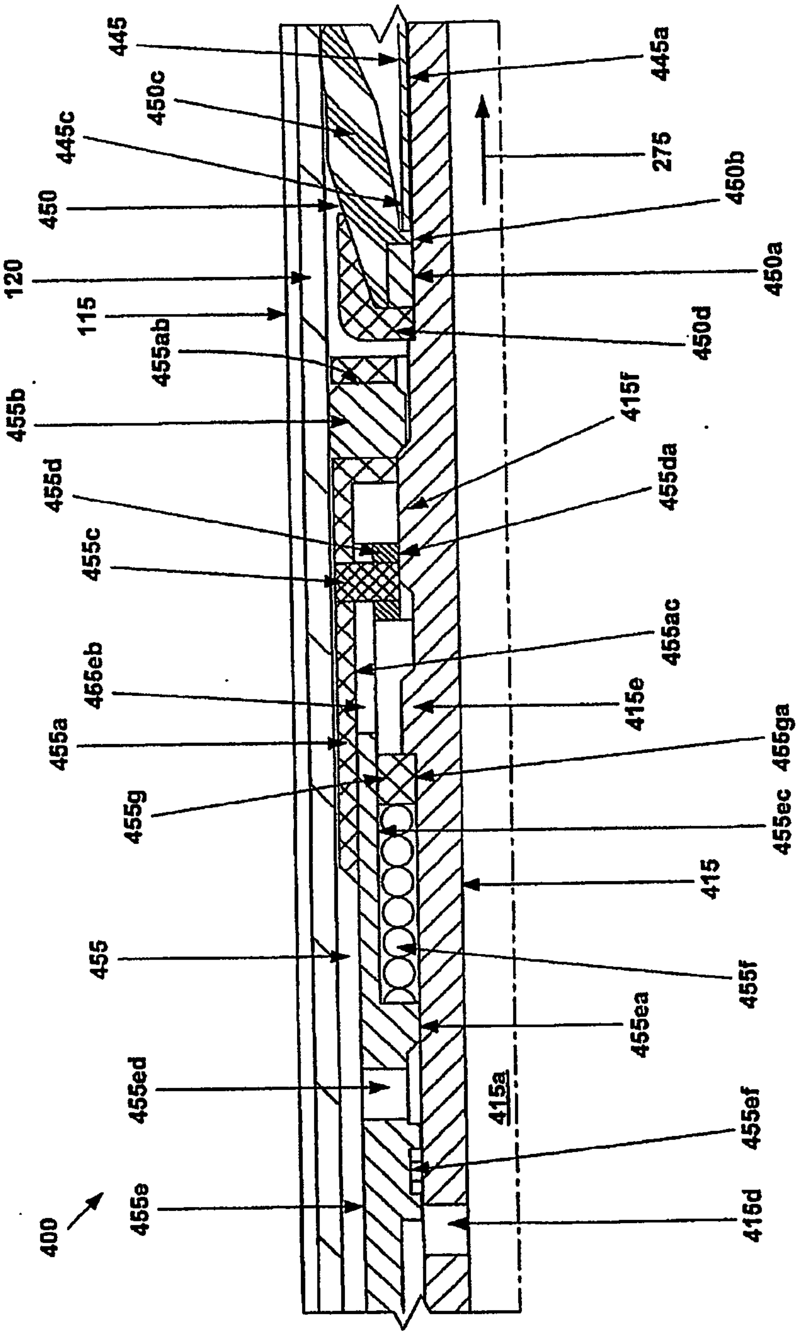
405a
400

Fig. 8a


445
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445c
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450b
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120
450a
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450d
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415f
455b
455da
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455c
455ac
455eb
415e
455a
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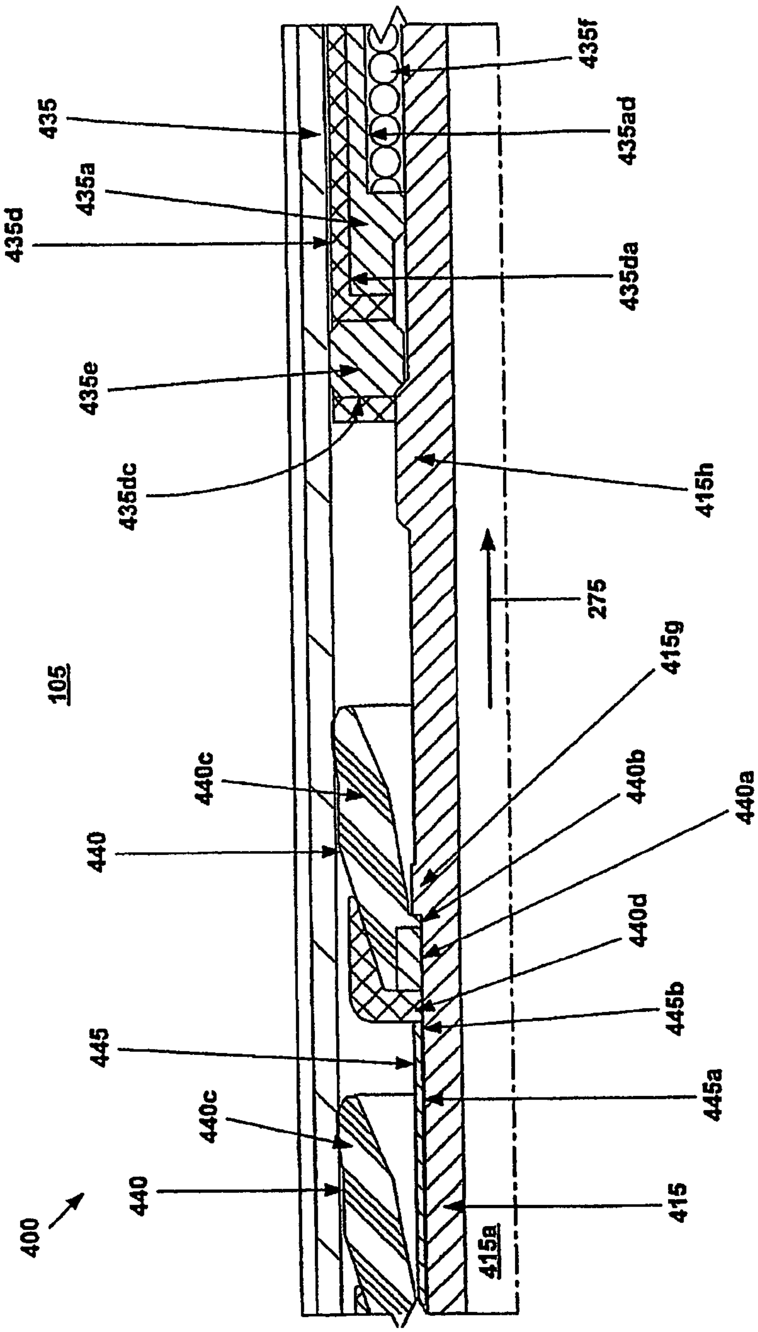
455g
455ec
415
455
455f
455ea
455ed
415a
455ef
455e
415d
400

Fig. 8b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435dc
415h
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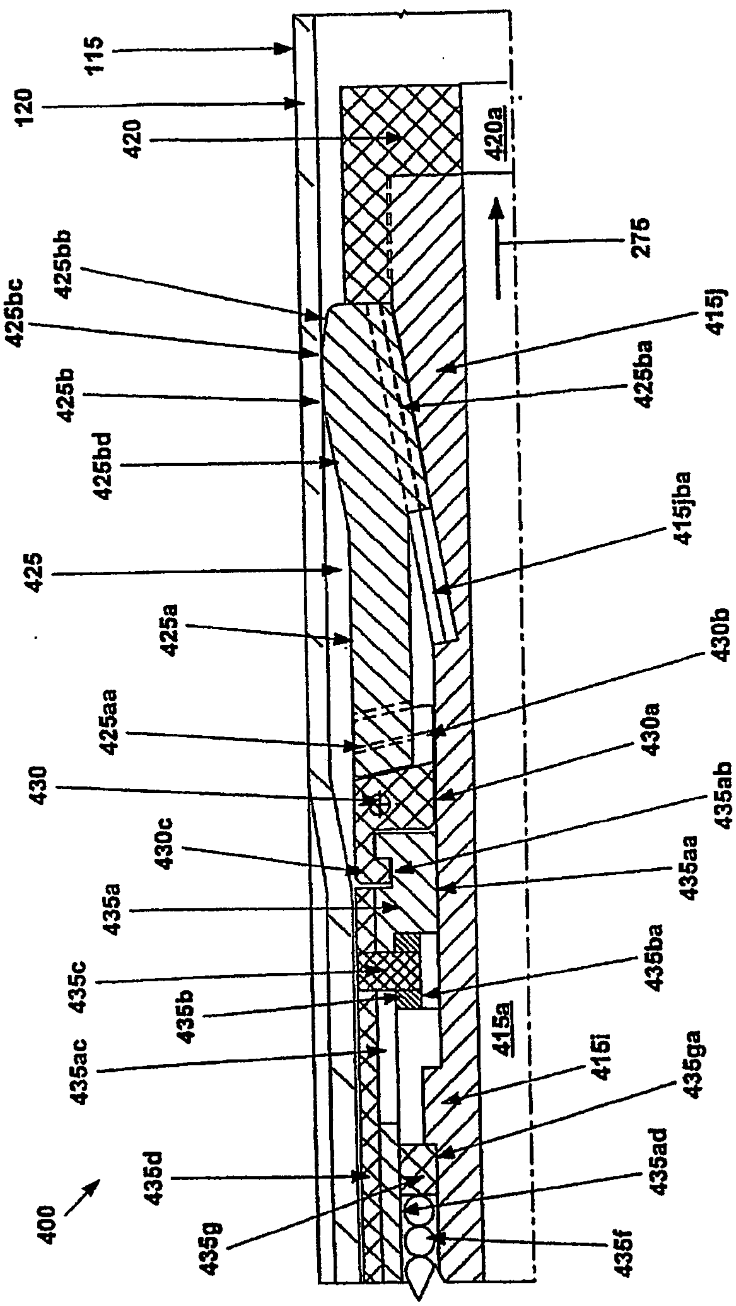
445
445a
440c
440
400
415
415a

Fig. 8c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435ab
430c
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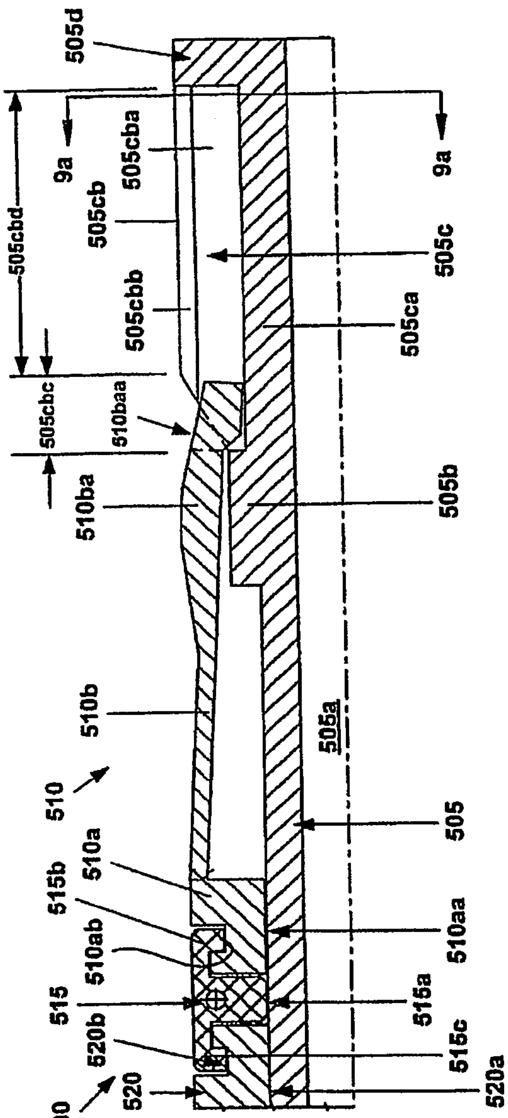
435d
435ad
400
435g
435f

Fig. 8d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515b
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9a
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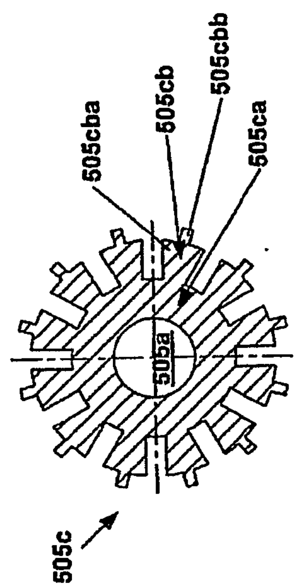
505
510aa
515a
515c
520a

Fig. 9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505c

Fig. 9a

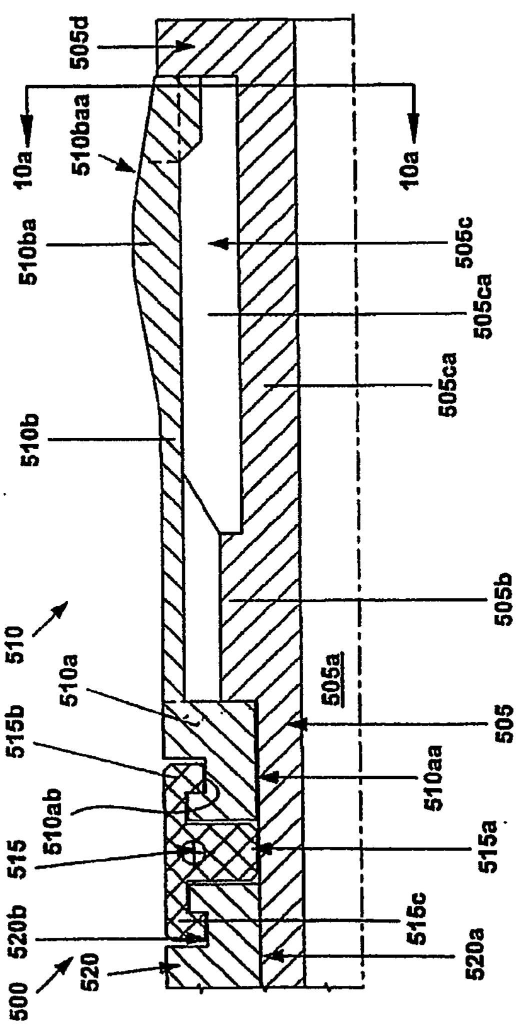



Fig. 10

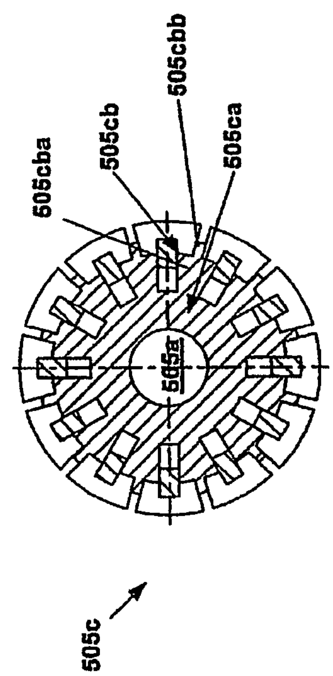



Fig. 10a

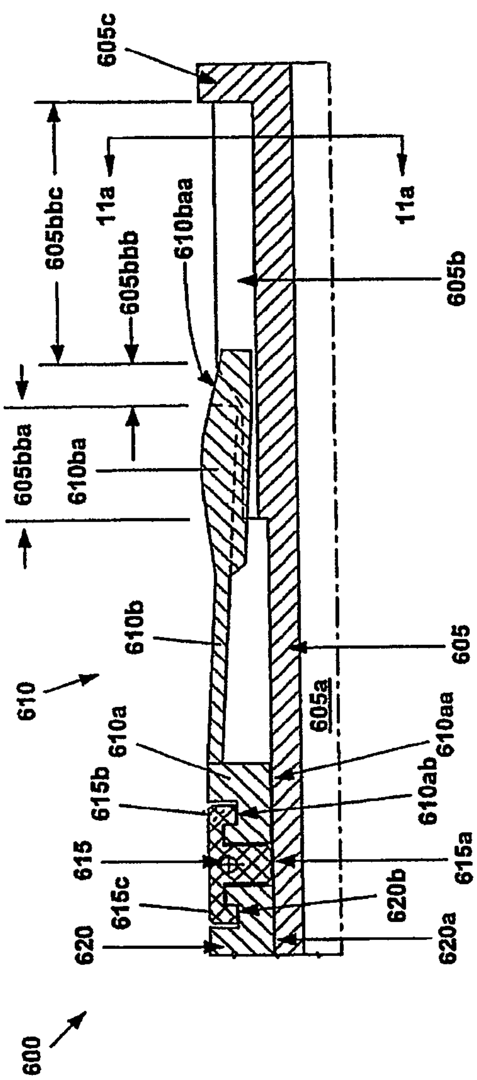



Fig. 11

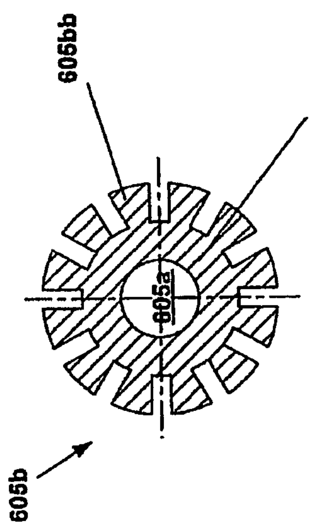



Fig. 11a

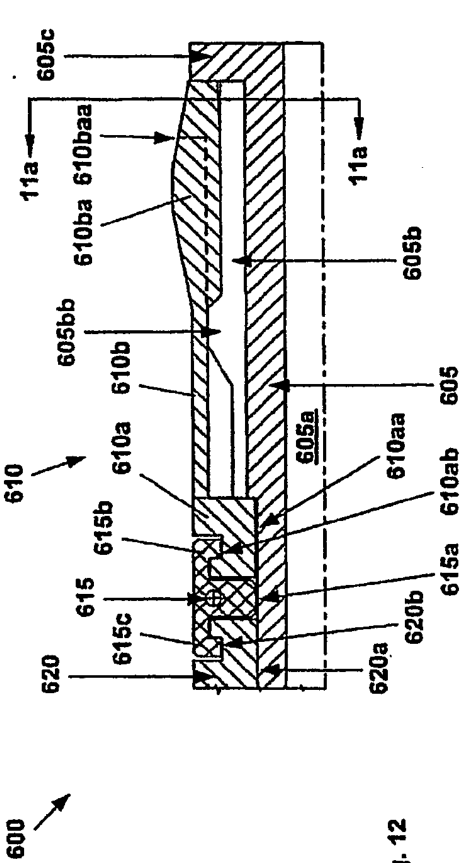



Fig. 12

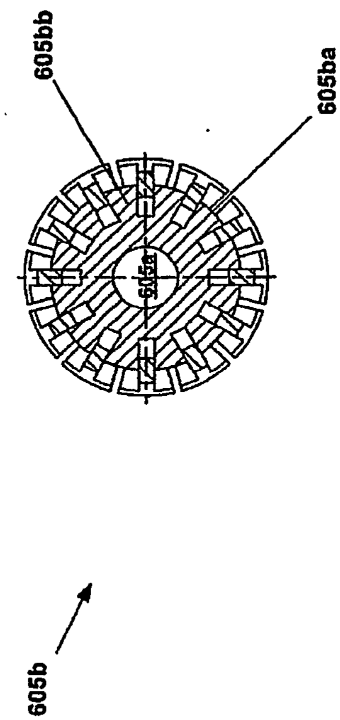



Fig. 12a

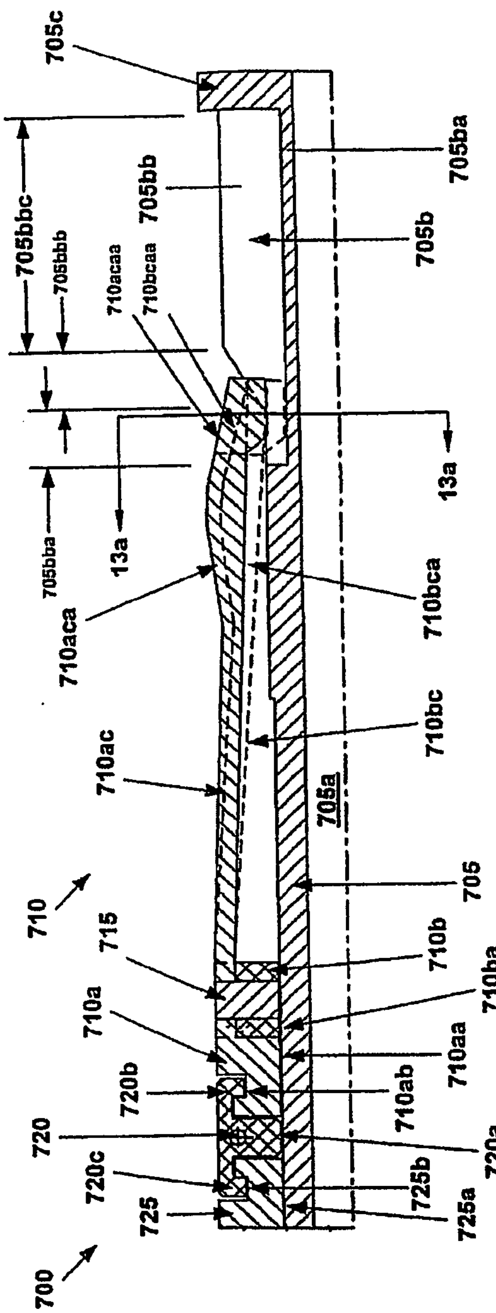



Fig . 13

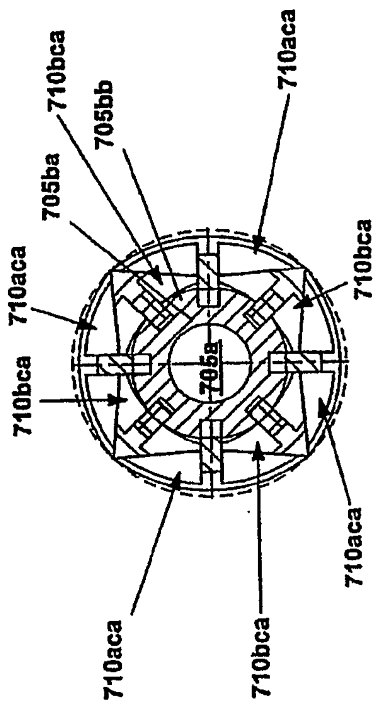
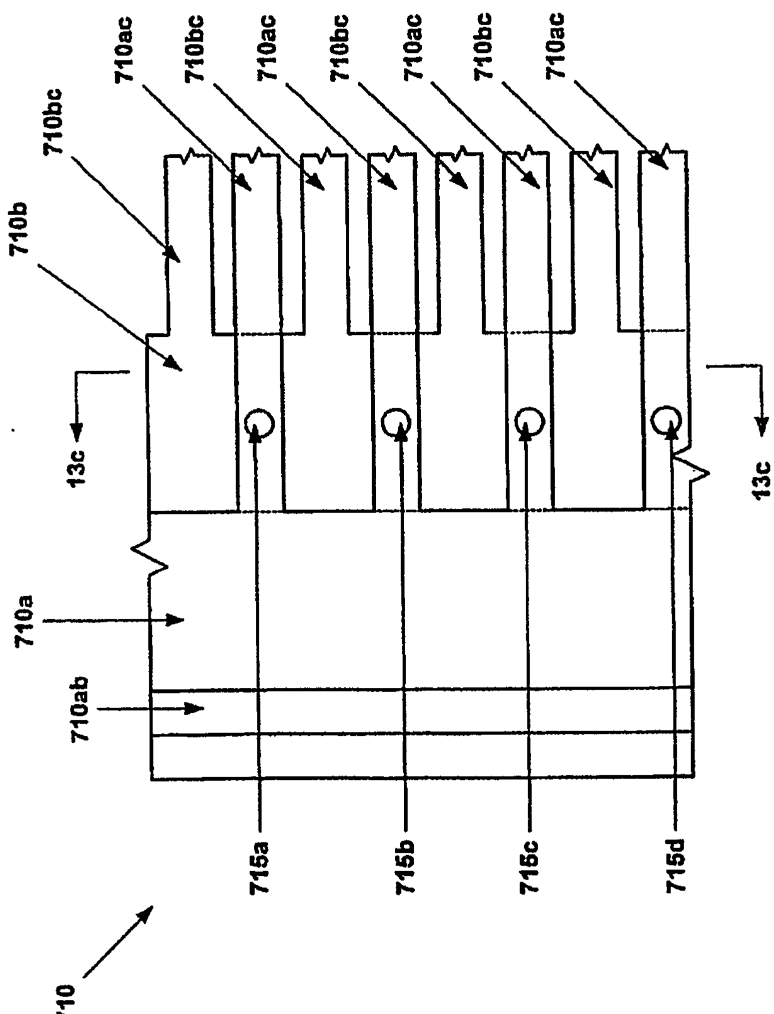



Fig. 13a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710ac
710bc
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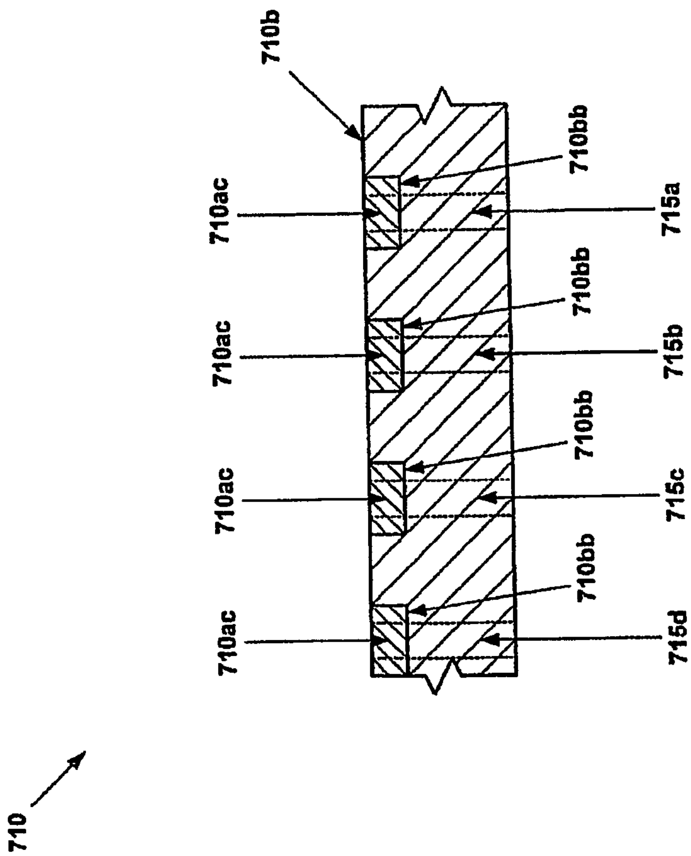
710b
13c
13c
710a
710ab
715a
715b
715c
715d
710

Fig. 13b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715c
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710bb
715d
710

Fig. 13c

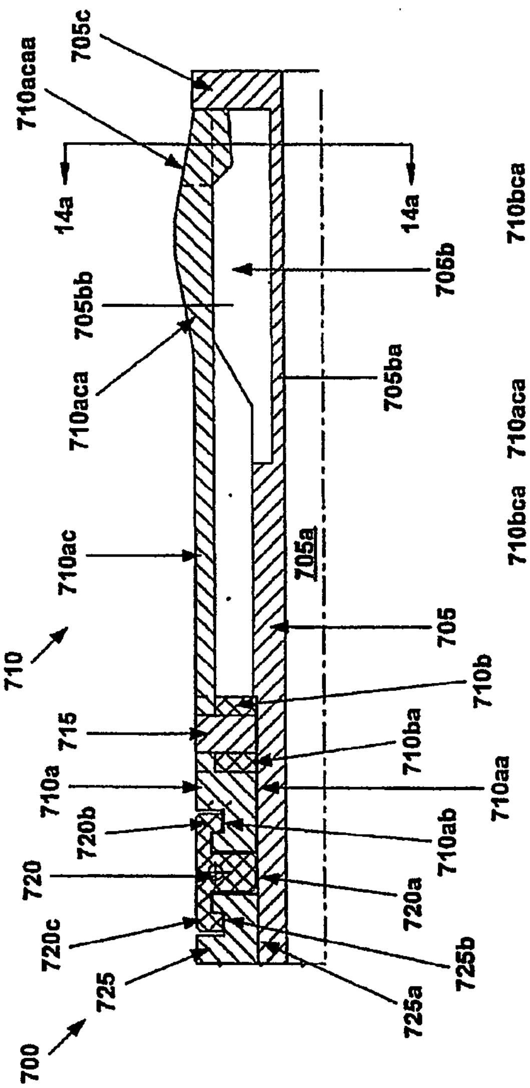



Fig. 14

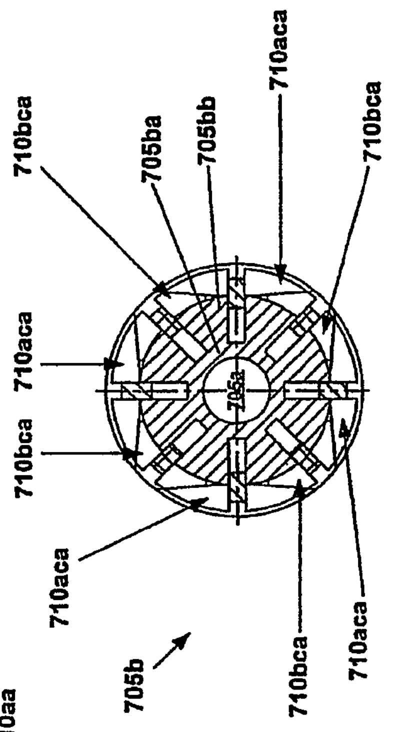
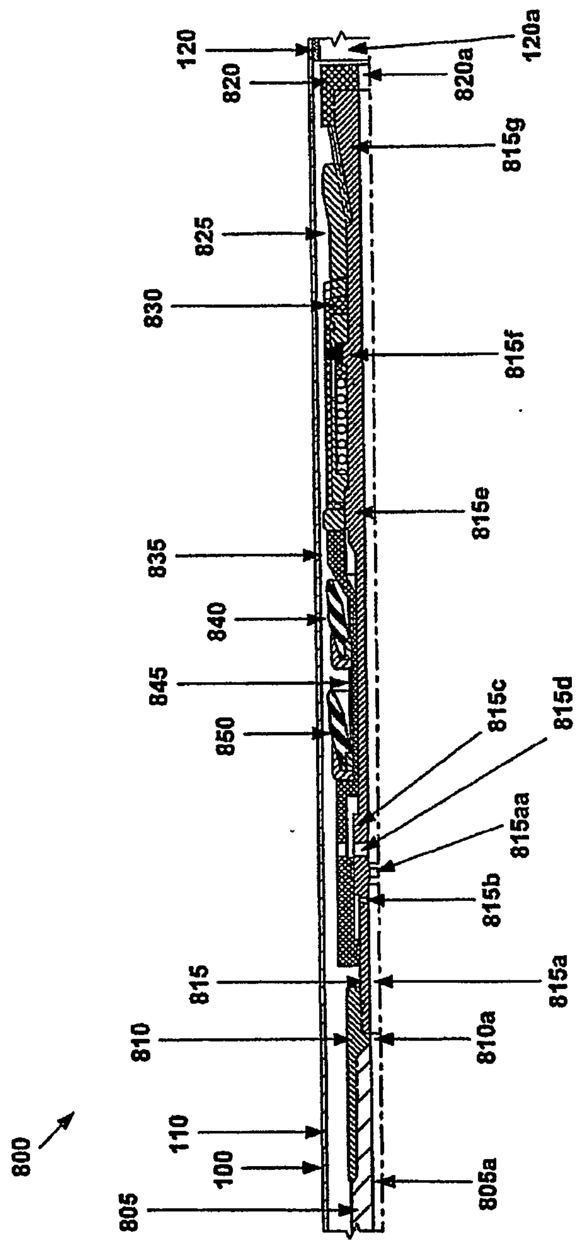



Fig. 14a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810a
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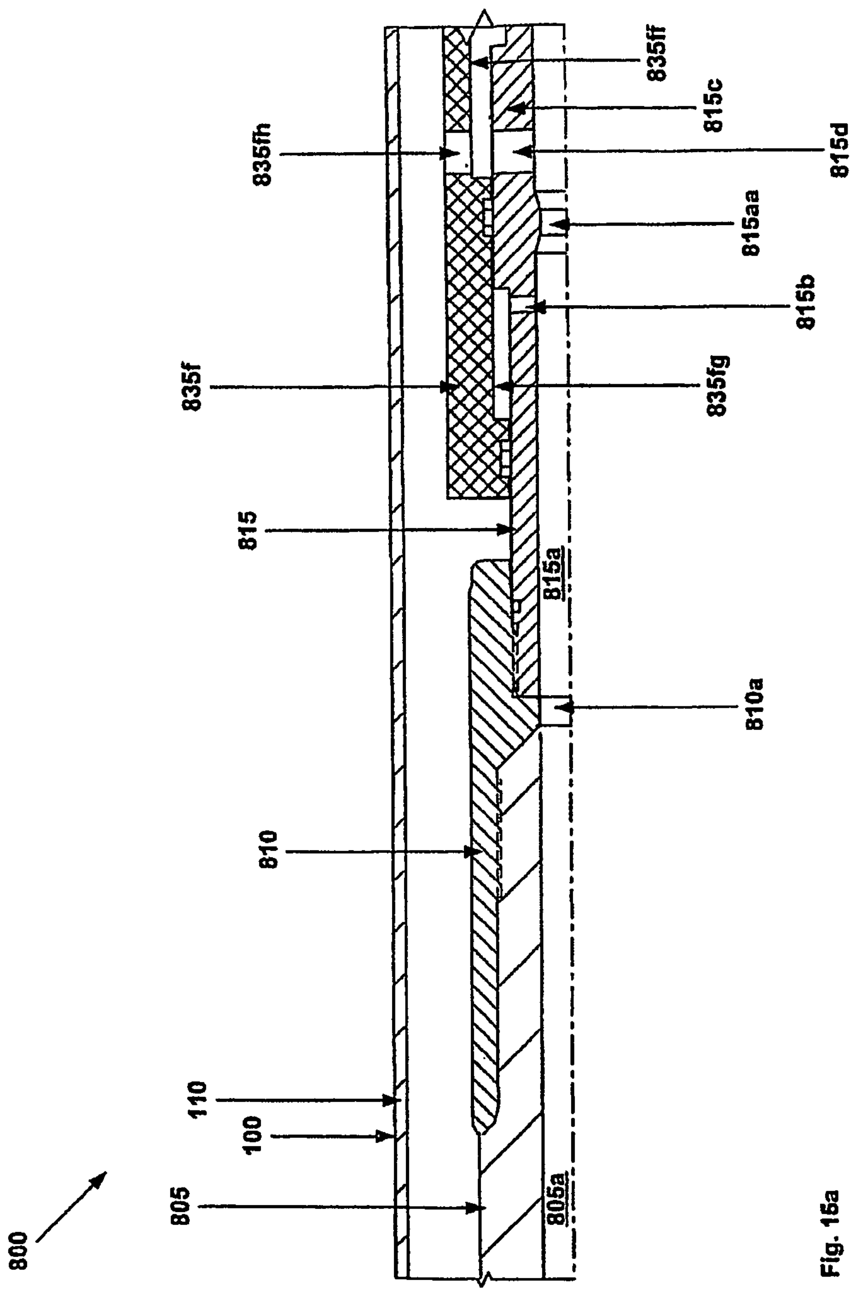
100
805
805a

Fig. 15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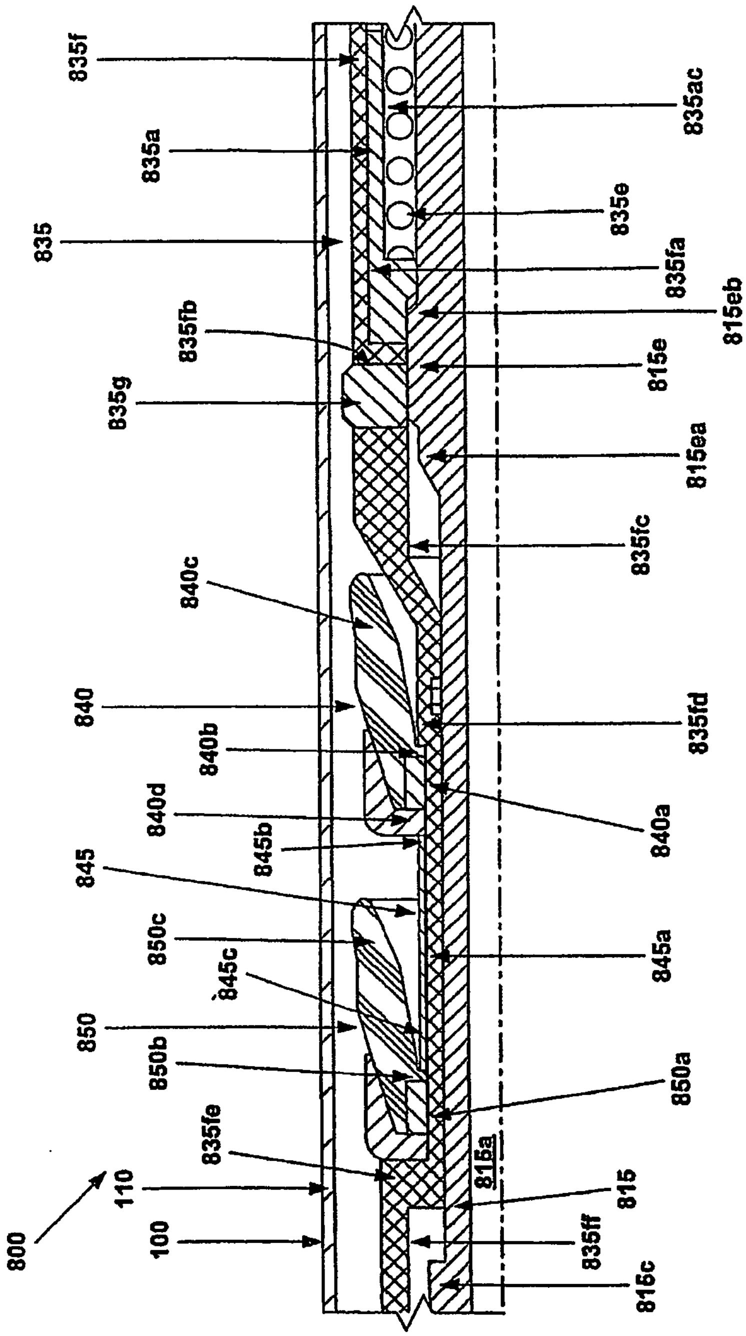
805
805a

Fig. 15a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110
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835ac
835e
835fa
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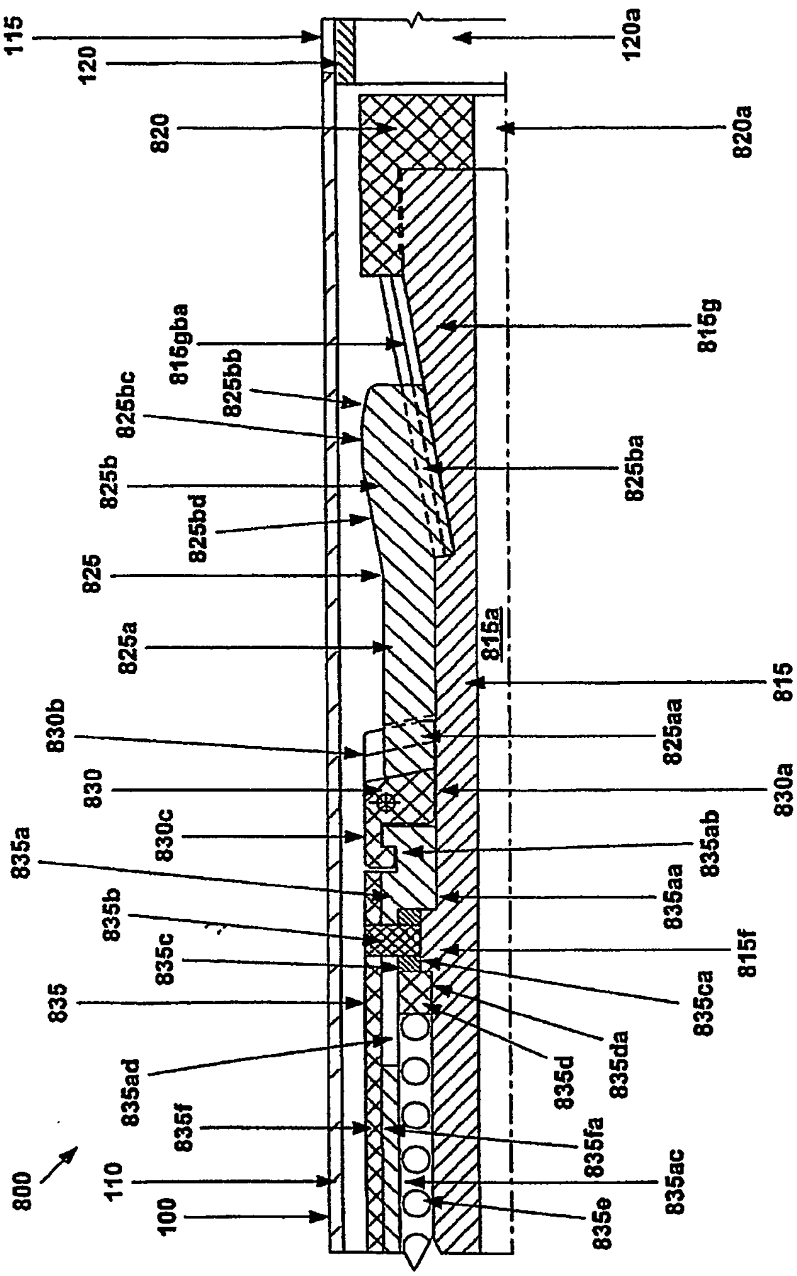
815a
815
835ff
815c

Fig. 15b



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835b
835c
815f
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100
835e


Fig. 15c

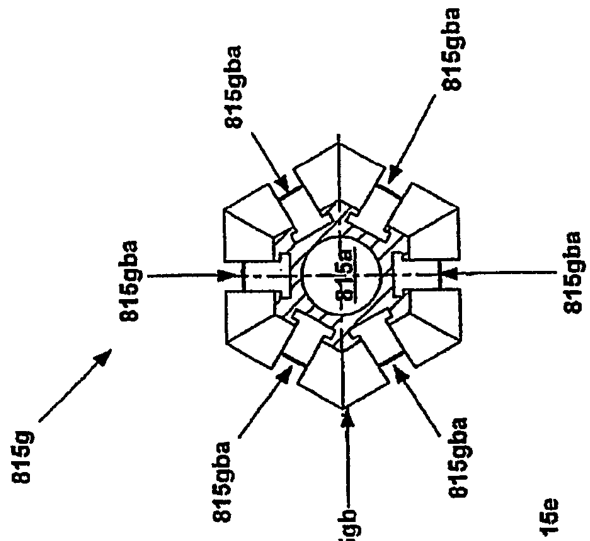



Fig. 15e

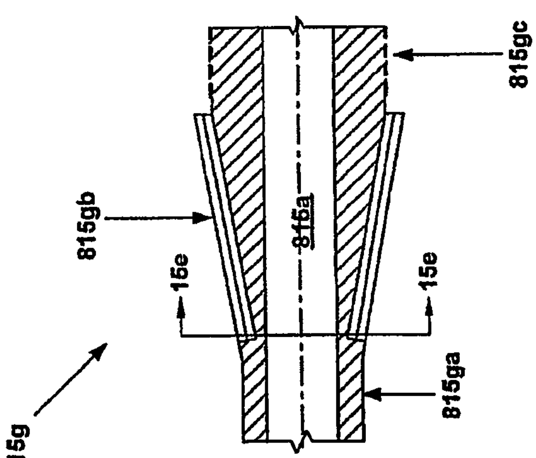



Fig. 15d

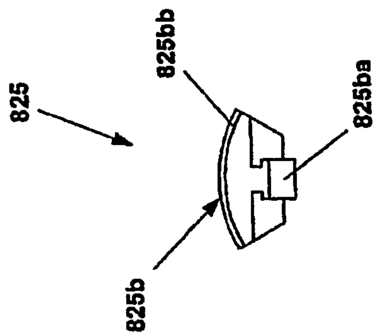



Fig. 15g

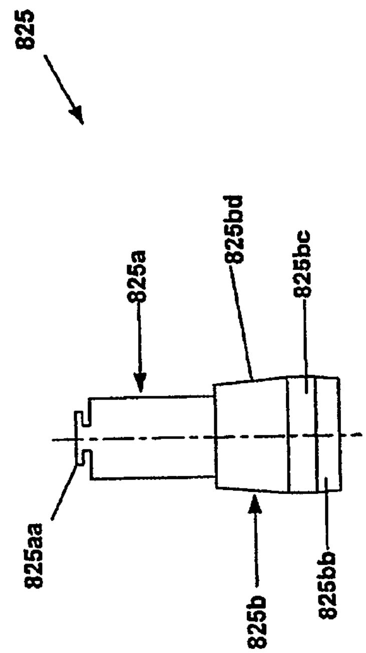



Fig. 15h

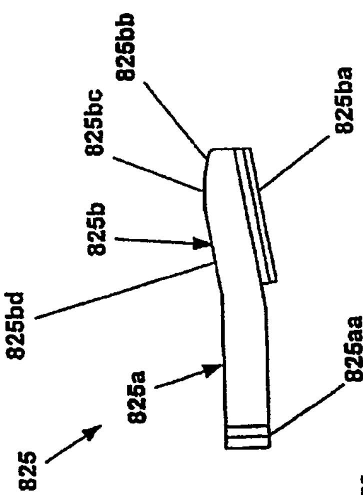
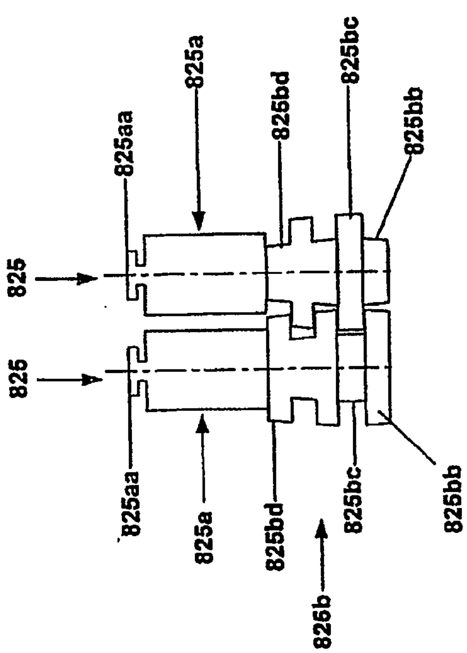



Fig. 15f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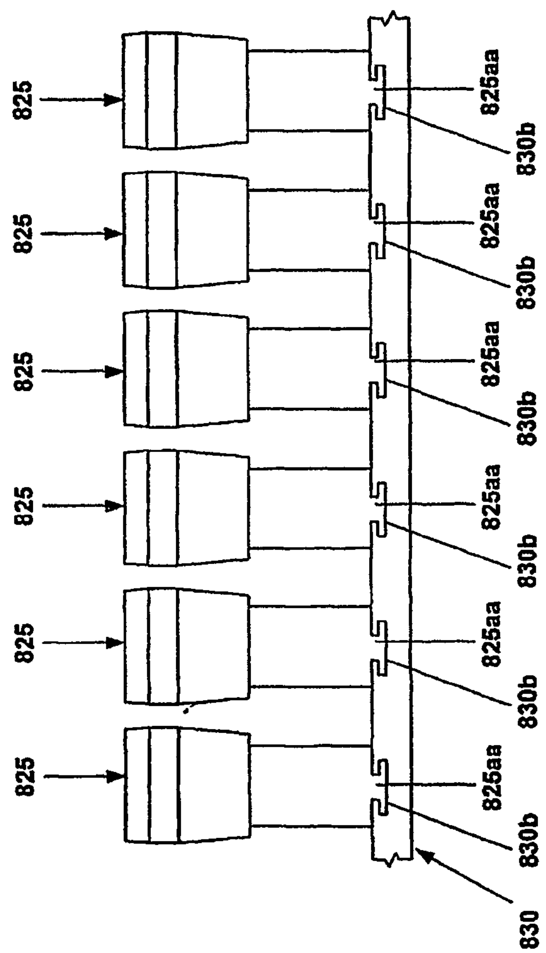
825bb
825aa
825a
825bd
825bc
825bb
825b

Fig. 15i


825
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825aa
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825aa
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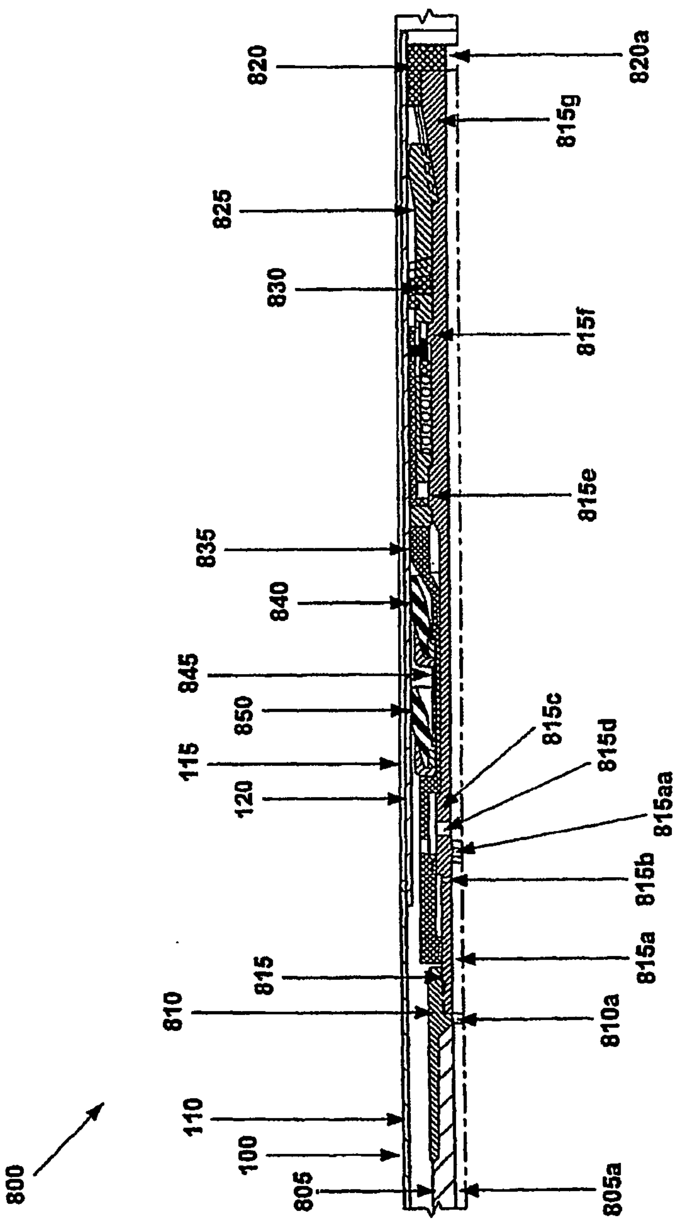
830b
830b
830b
830b
830b
830

Fig. 15j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835
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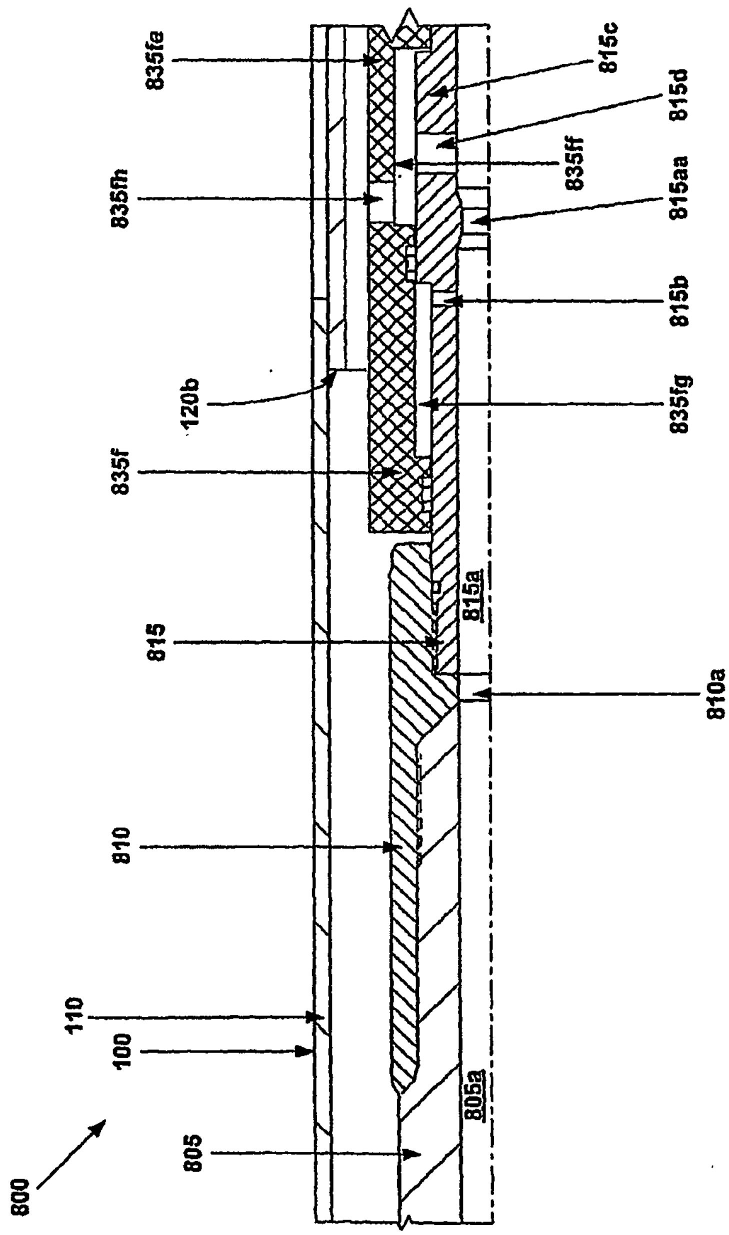
810a
805a

Fig. 16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810
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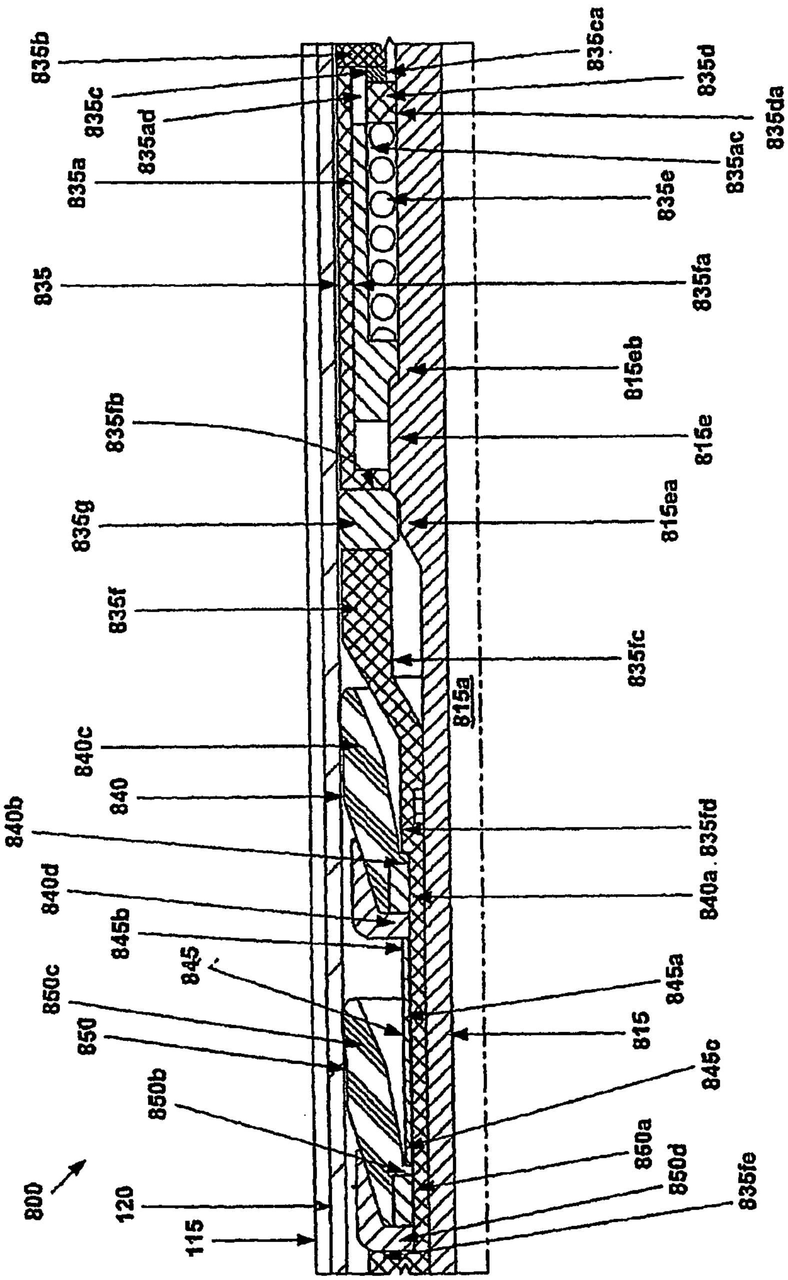
100
805a
805
800

Fig. 16a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840d
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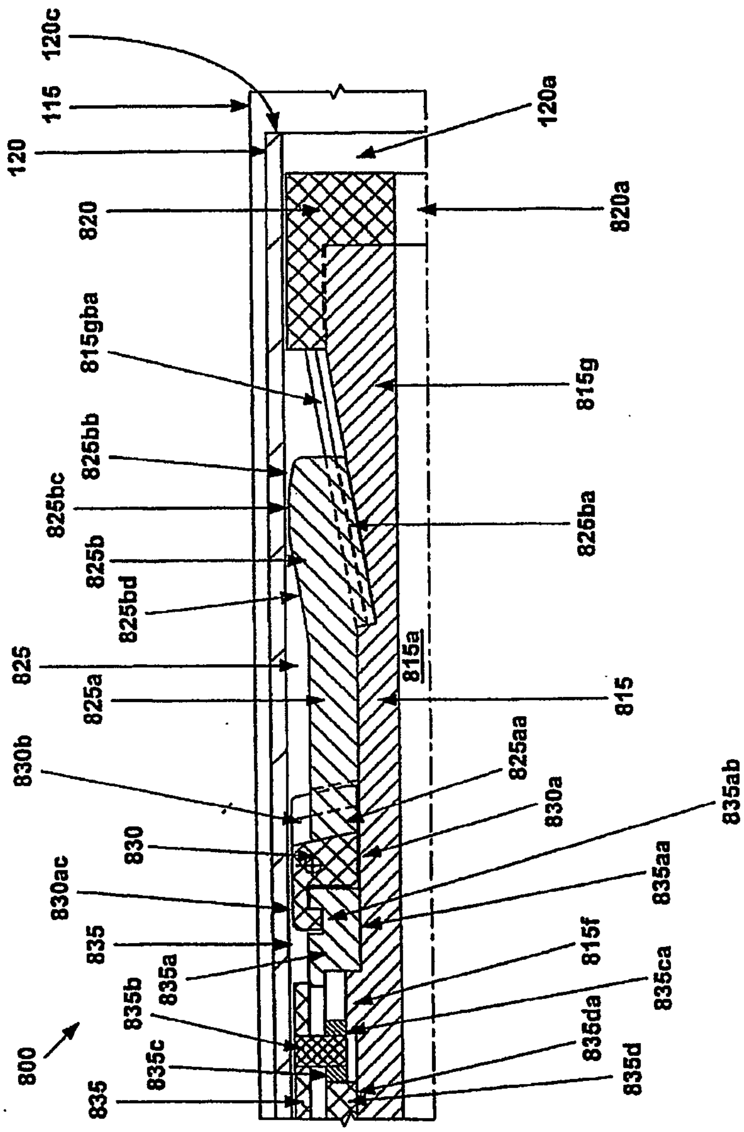
120
835fe
115

Fig. 16b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830
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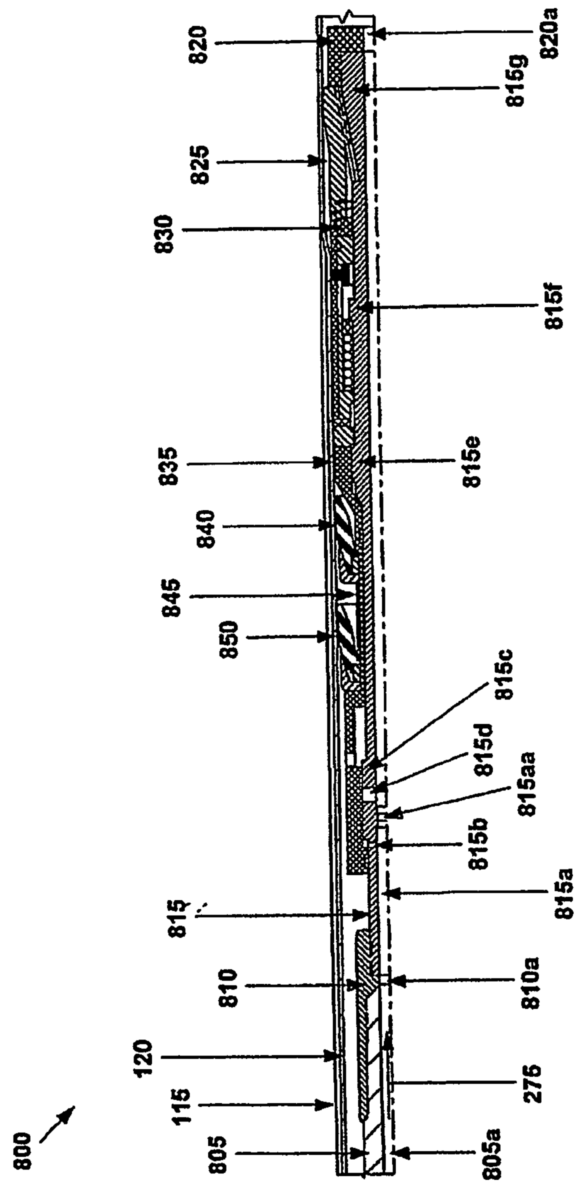
835

Fig. 16c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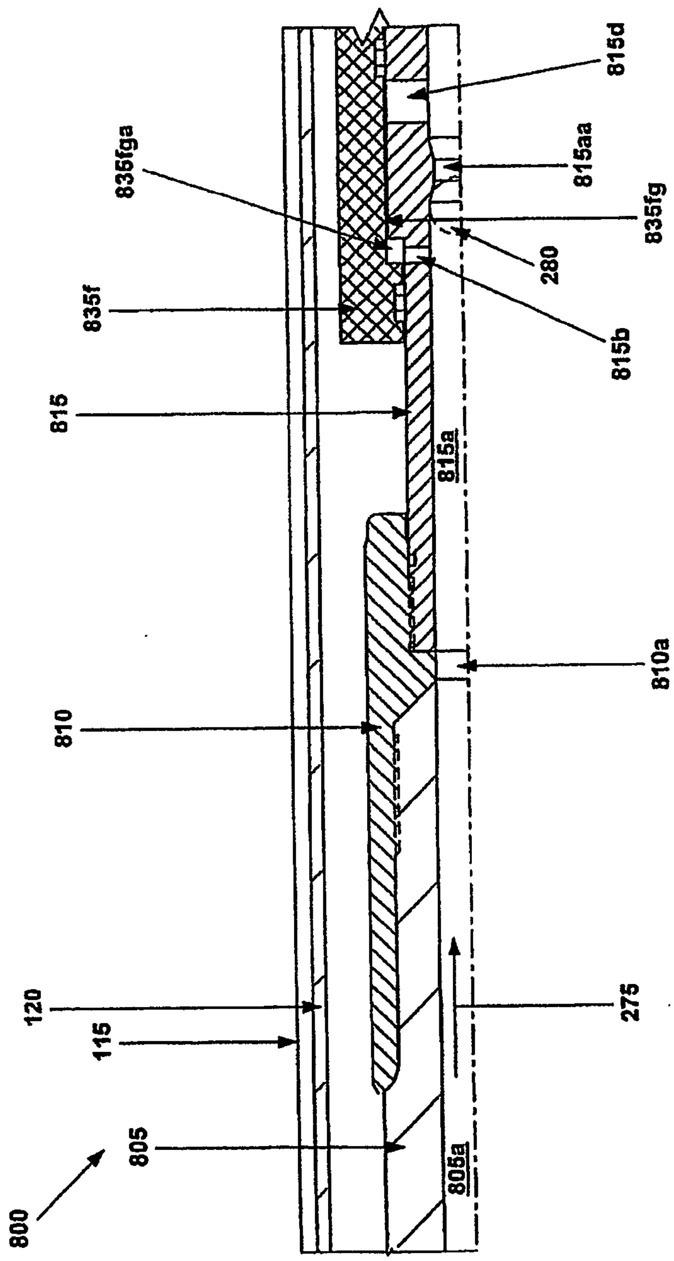
810a
276
805a

Fig. 17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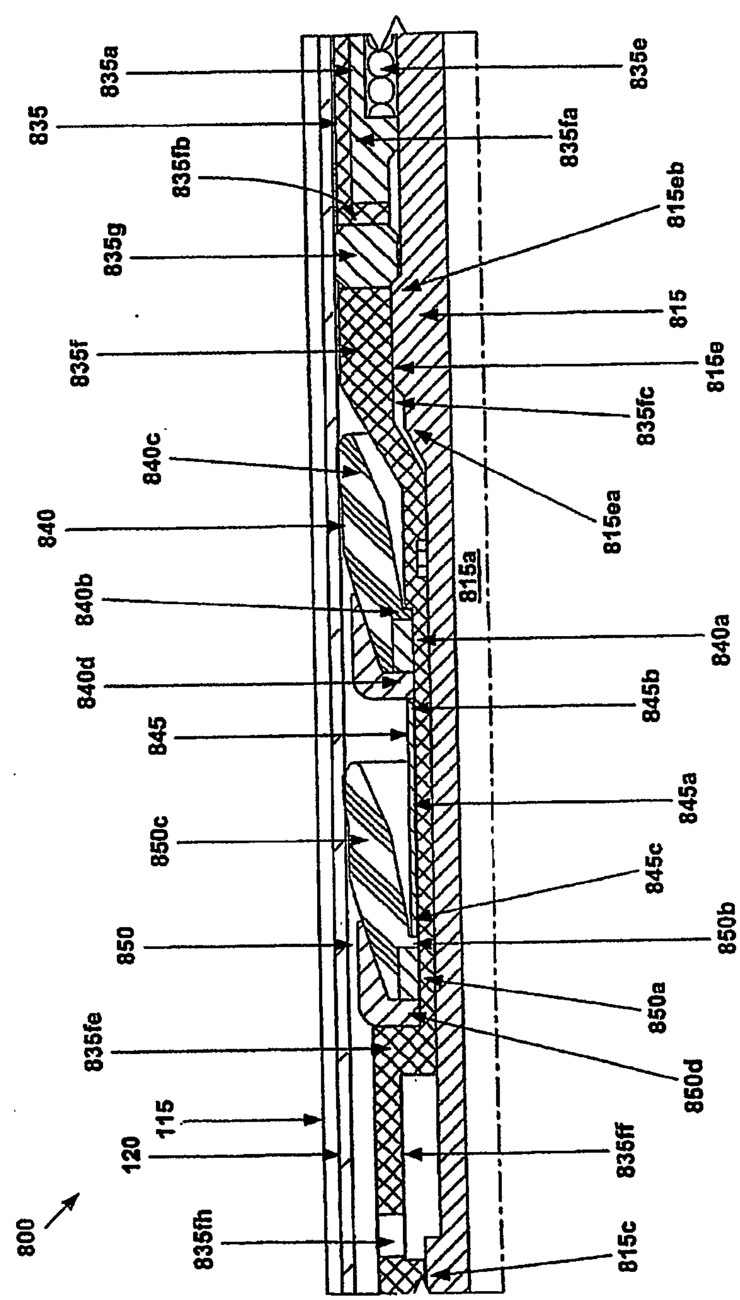
805
805a

Fig. 17a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845
845a
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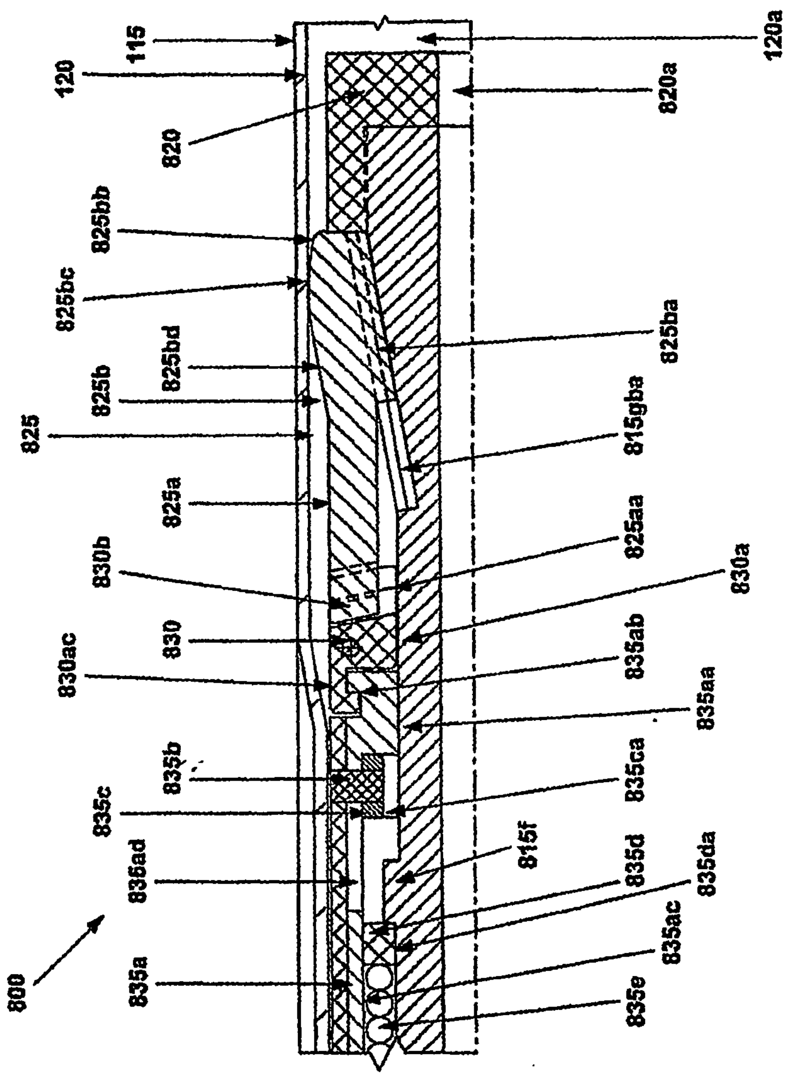
815c

Fig. 17b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820a
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835da
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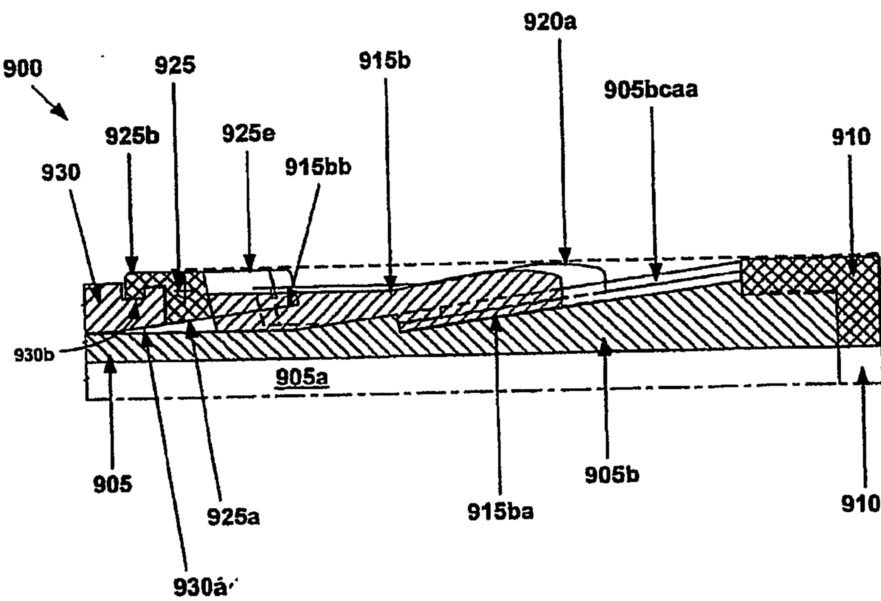
835e

Fig. 17c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905
925a
915ba
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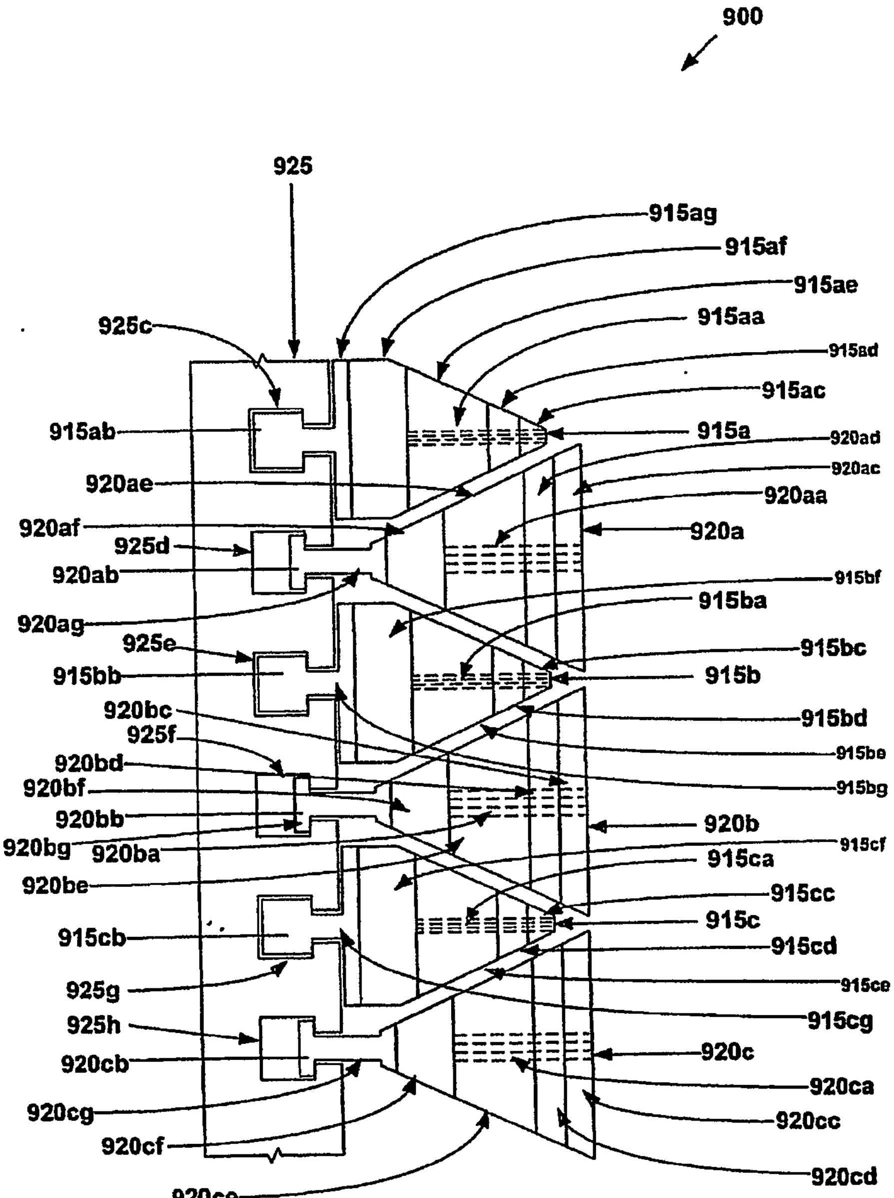
910a
930a

Fig. 18a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920be
915ca
915cc
915cb
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Fig. 18b

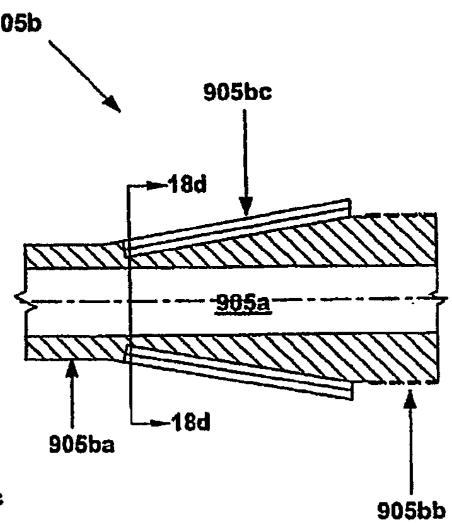



Fig. 18c

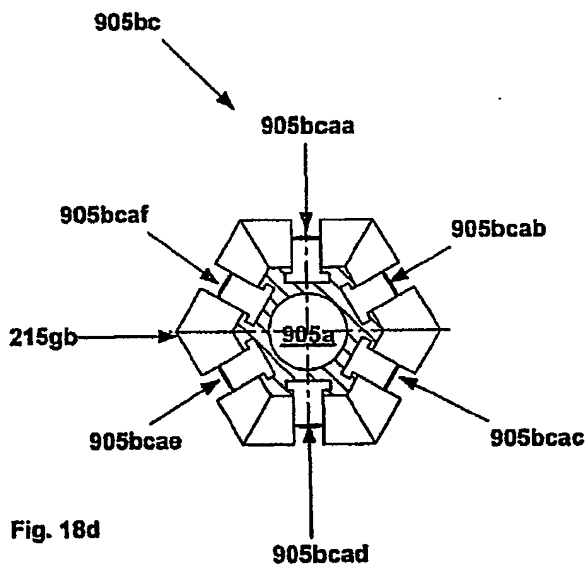
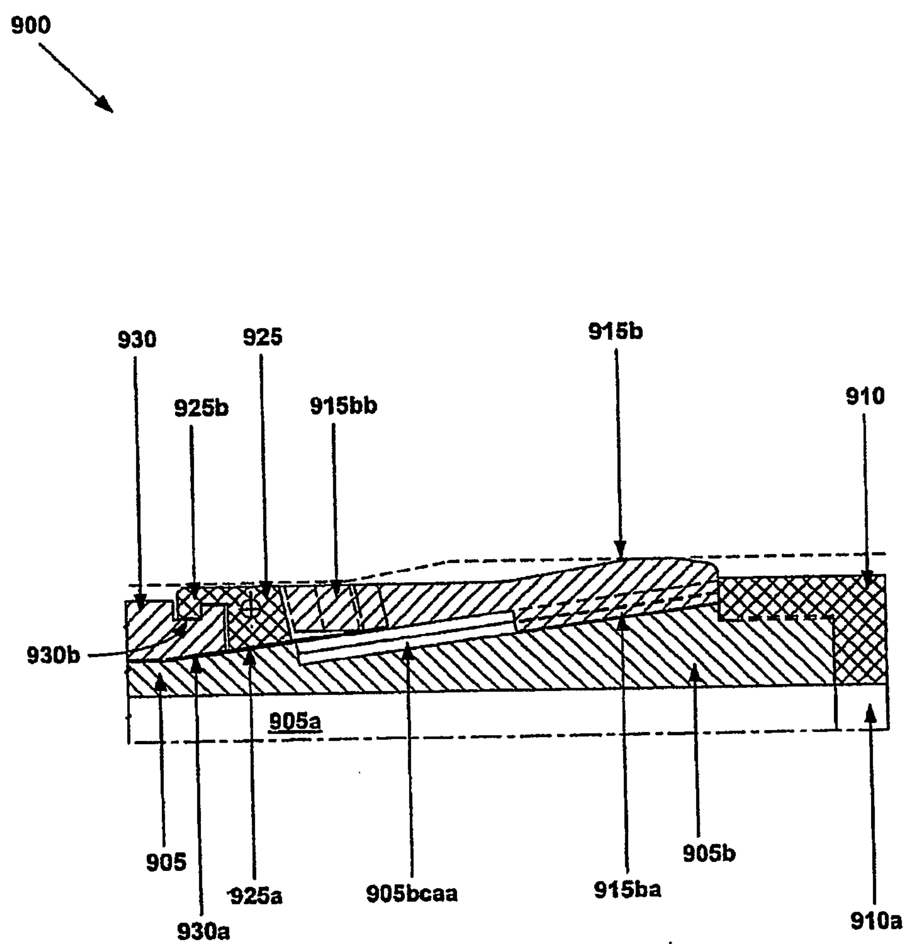



Fig. 18d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910a

Fig. 19a

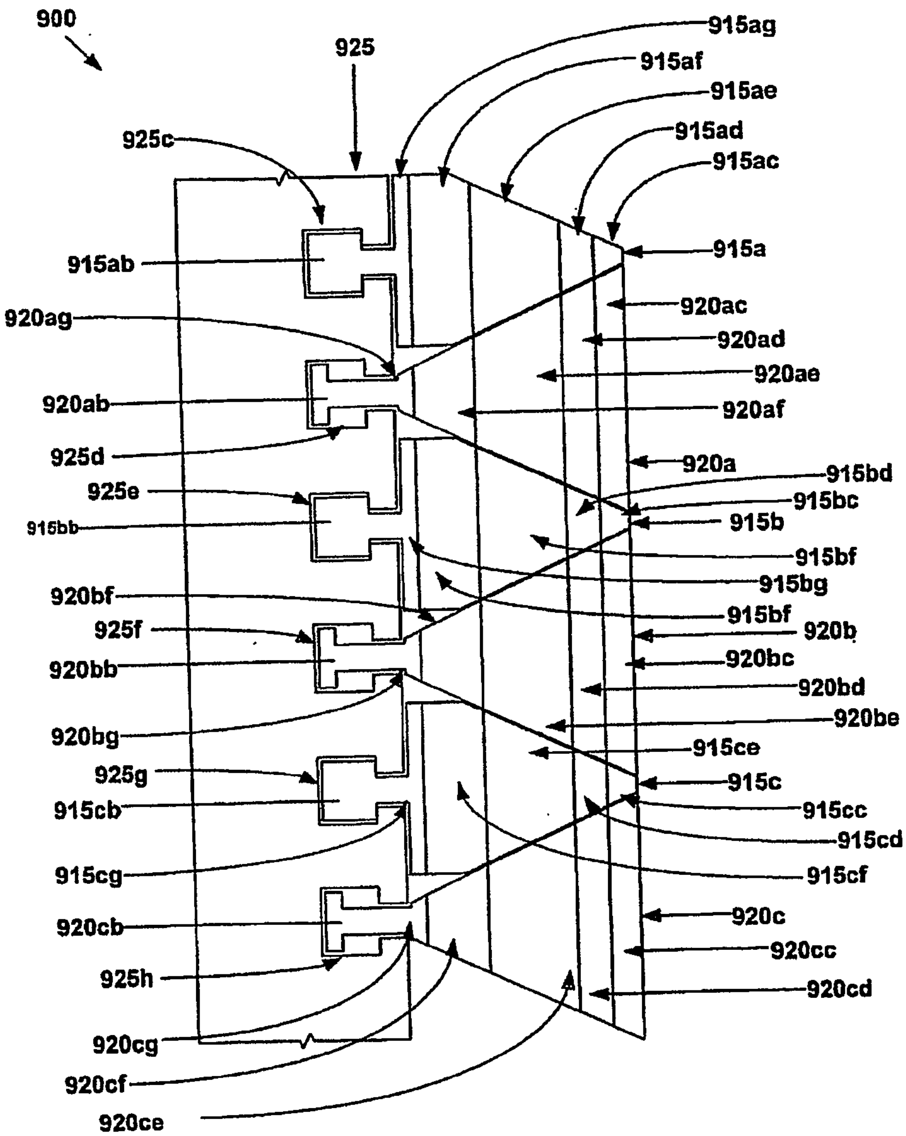
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Fig. 19b

82/87

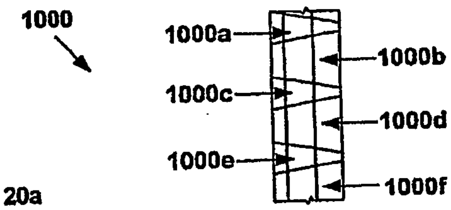



Fig. 20a

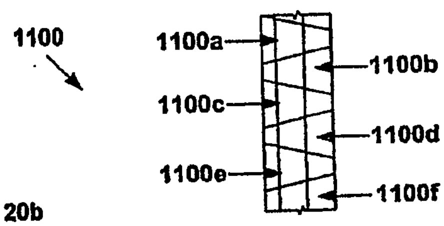



Fig. 20b

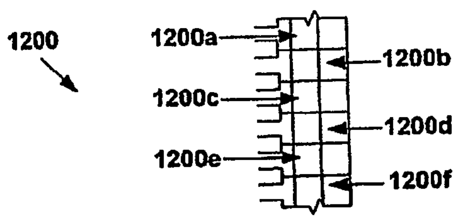



Fig. 20c

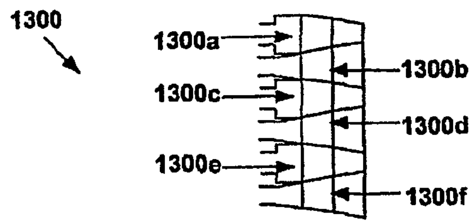



Fig. 20d

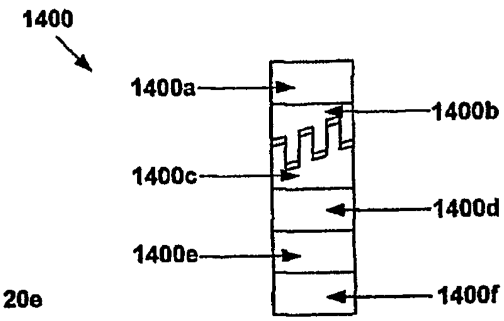



Fig. 20e

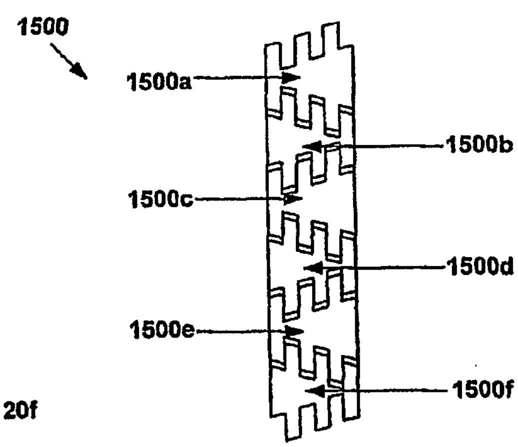



Fig. 20f

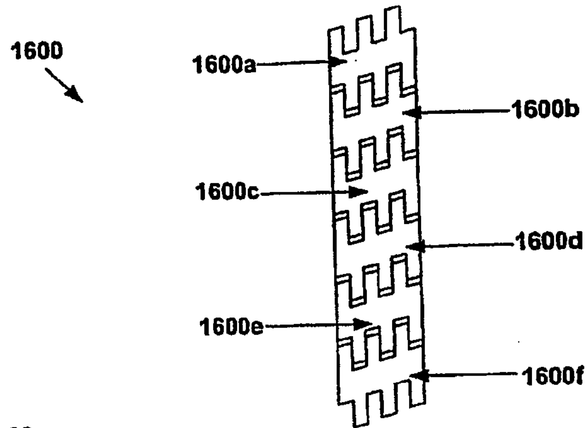



Fig. 20g

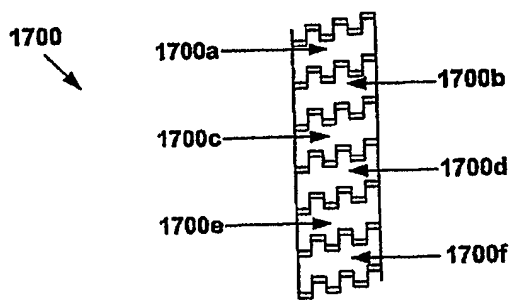



Fig. 20h

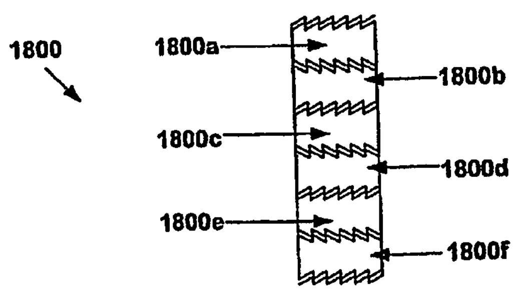



Fig. 20i

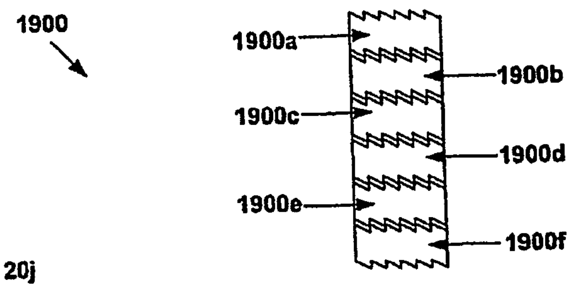



Fig. 20j

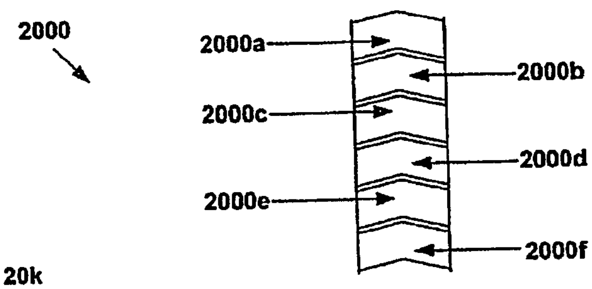



Fig. 20k

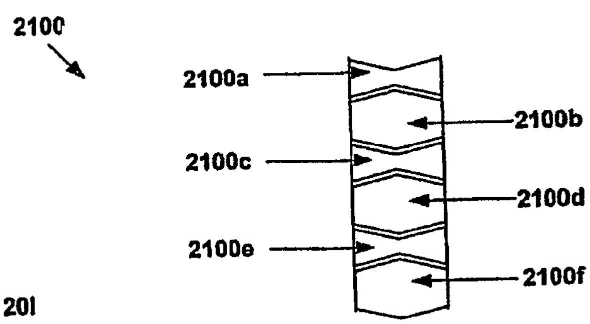



Fig. 20l

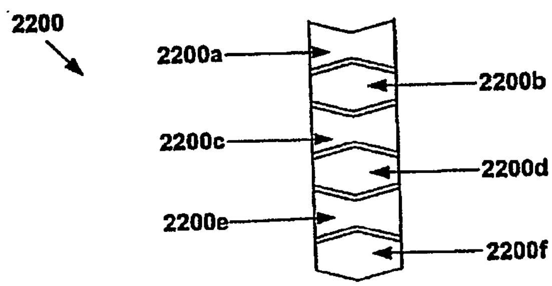



Fig. 20m

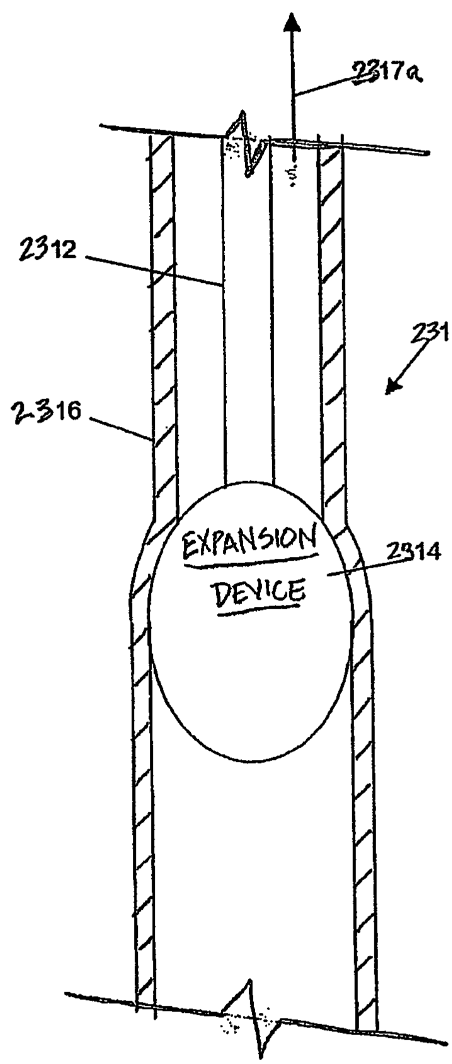



Fig.21a

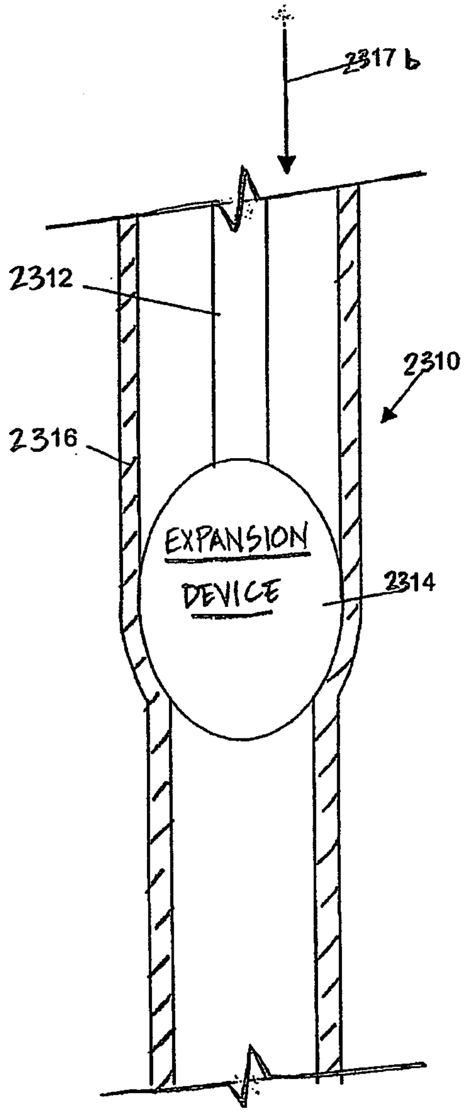



Fig.21b

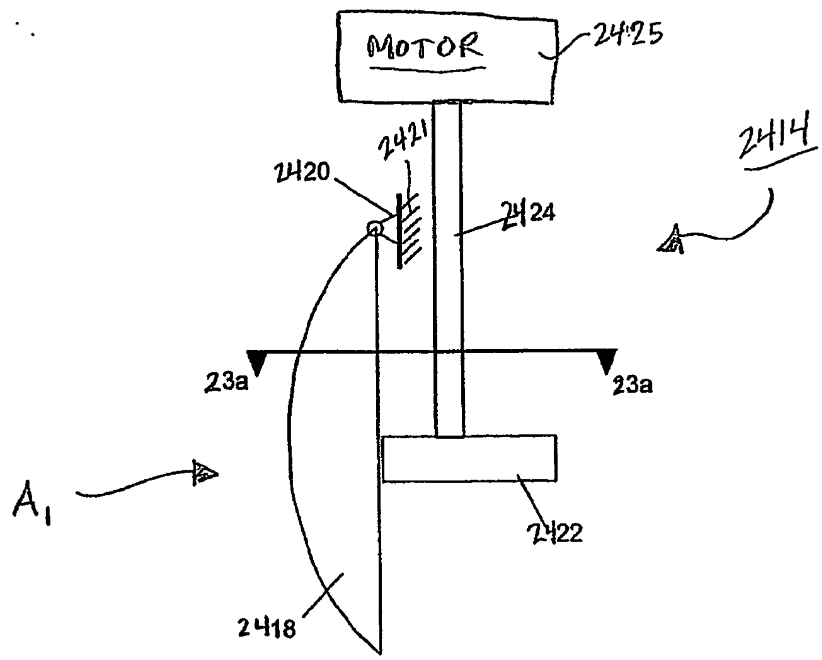



Fig.22a

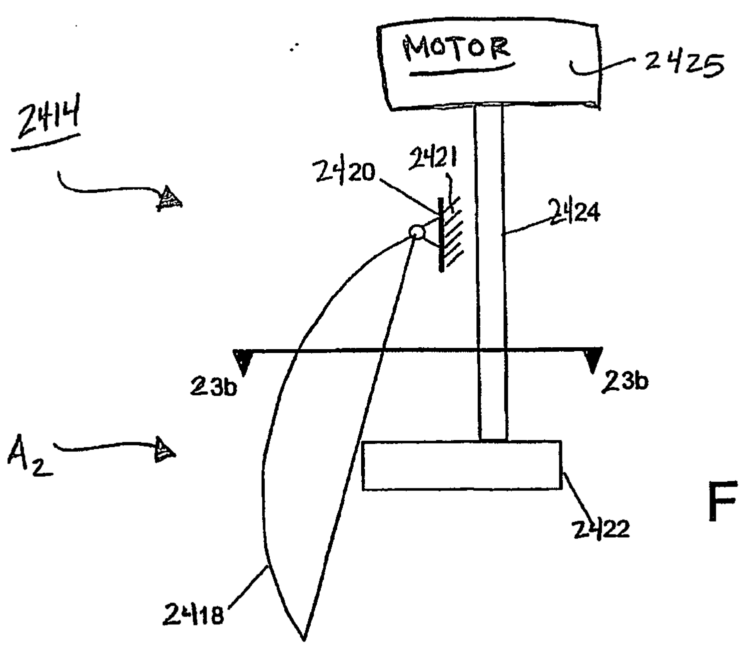



Fig.22b

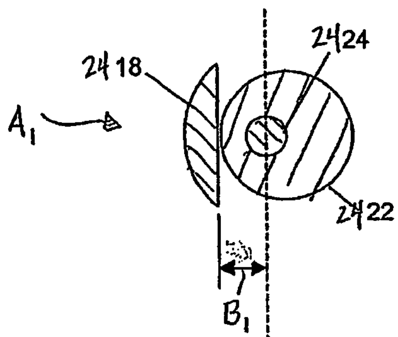



Fig.23a

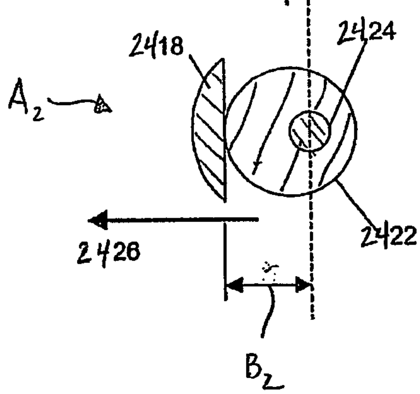
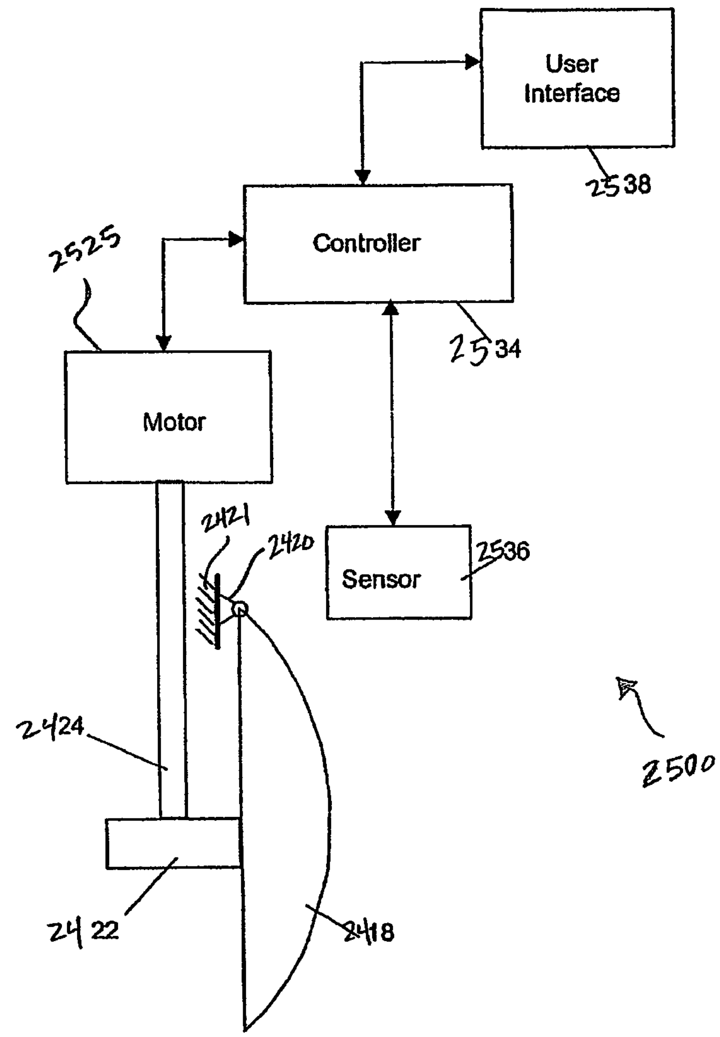



Fig.23b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2422
2418

Fig.24

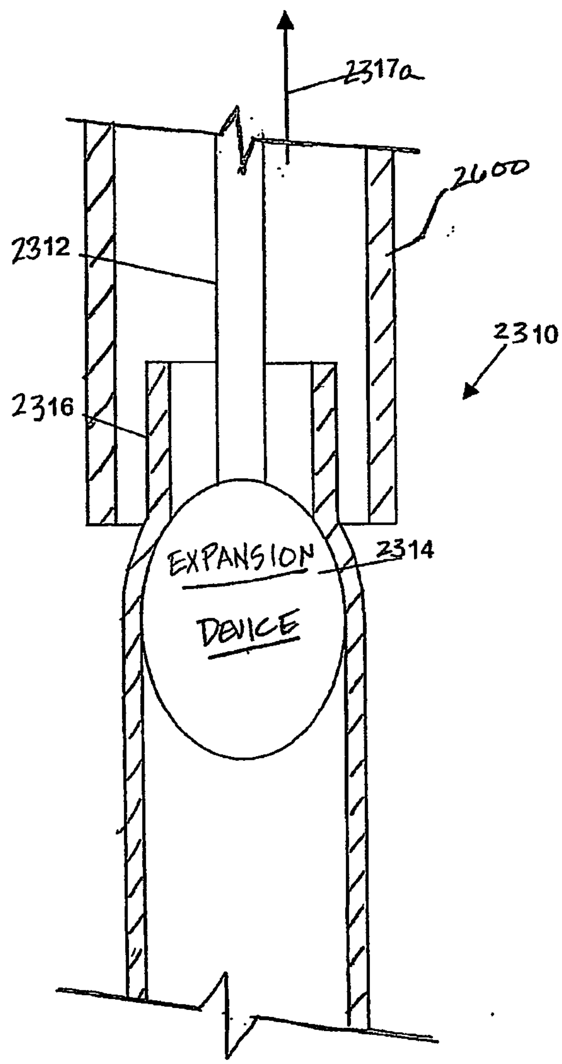


Fig.25a

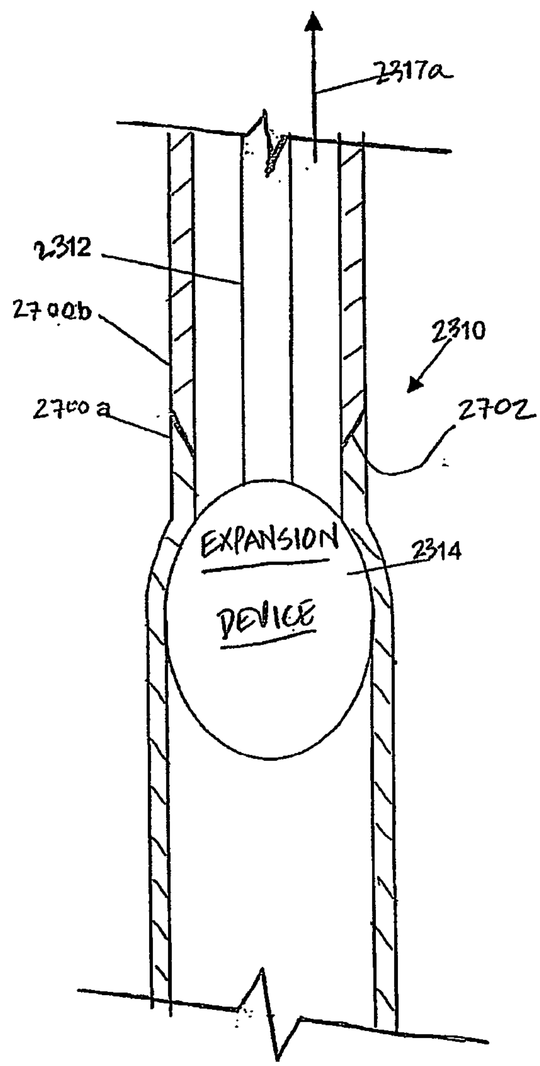


Fig.25b

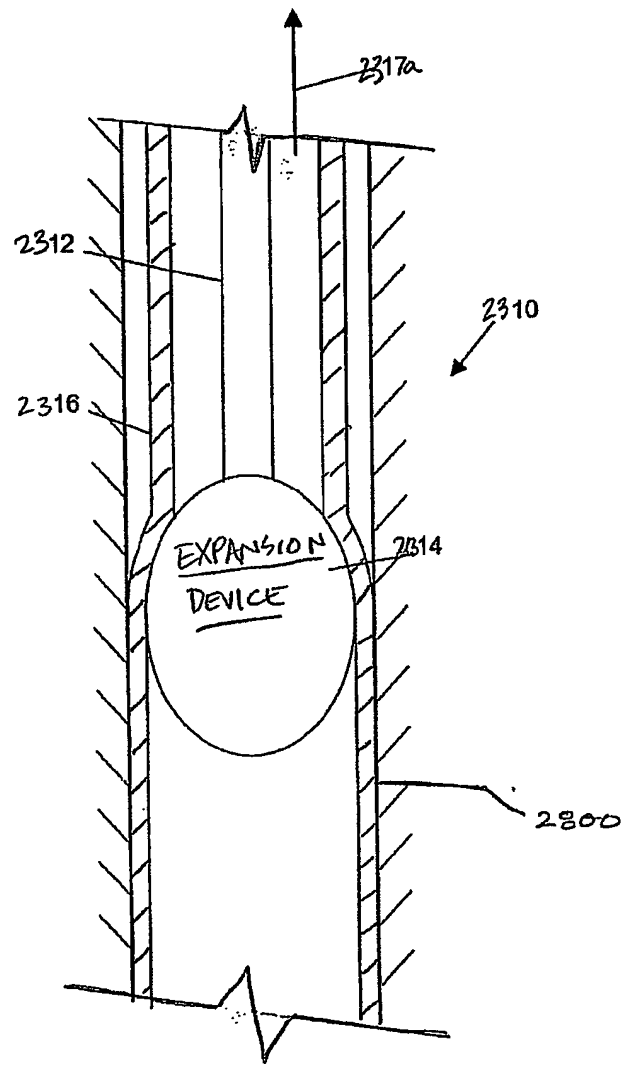


Fig.25c

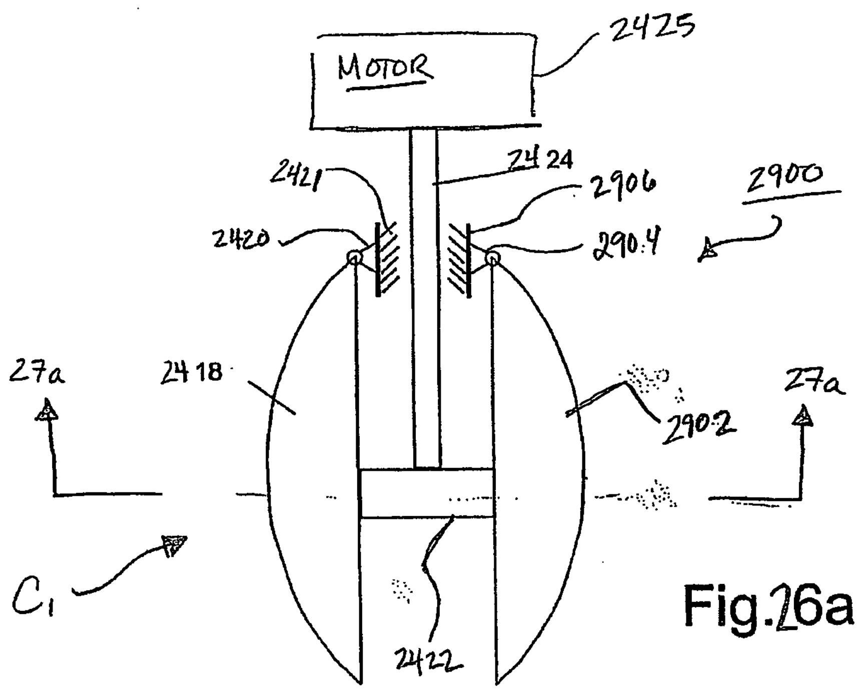


Fig.26a

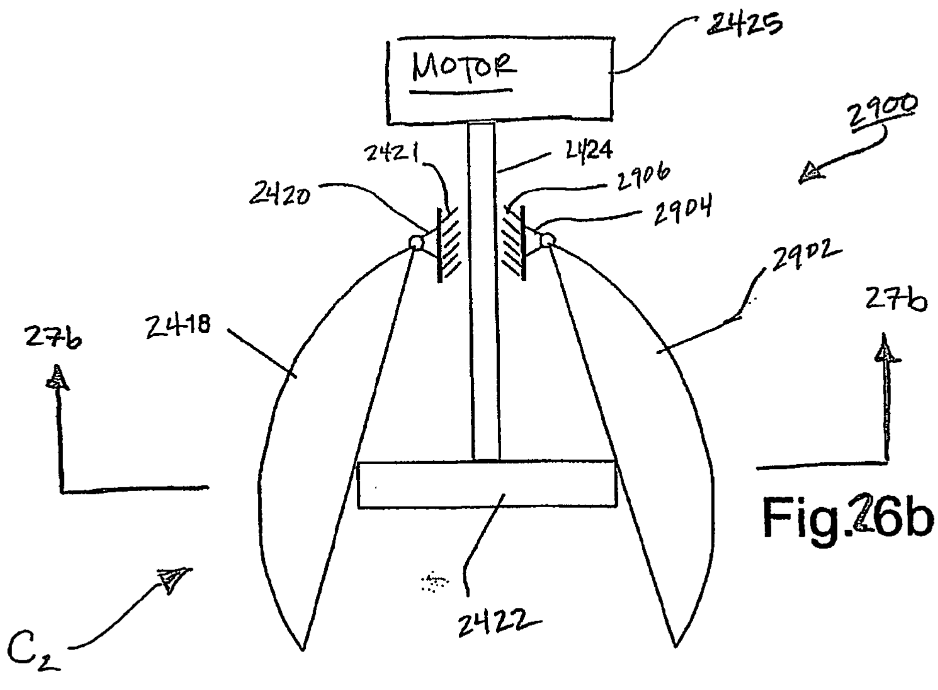


Fig.26b

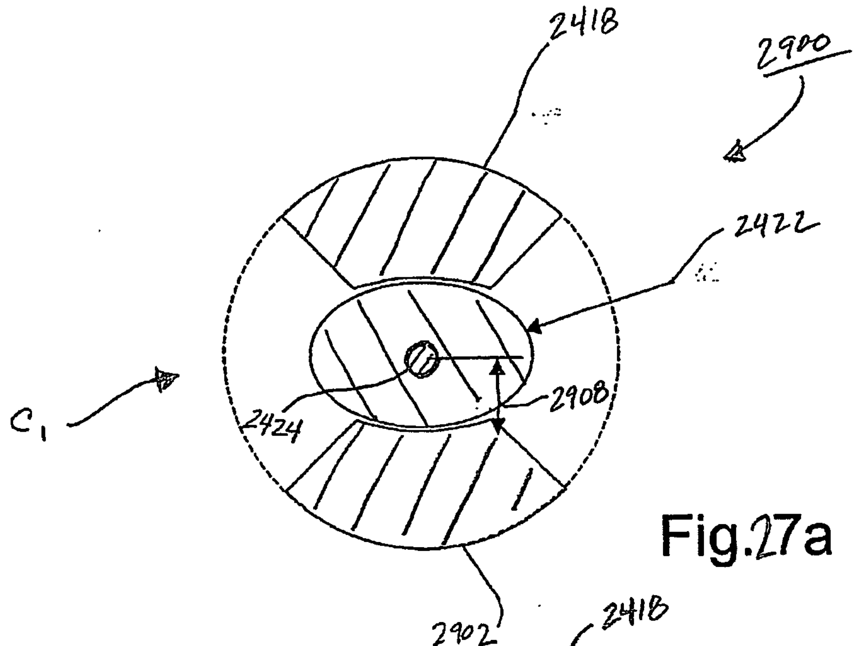


Fig.27a

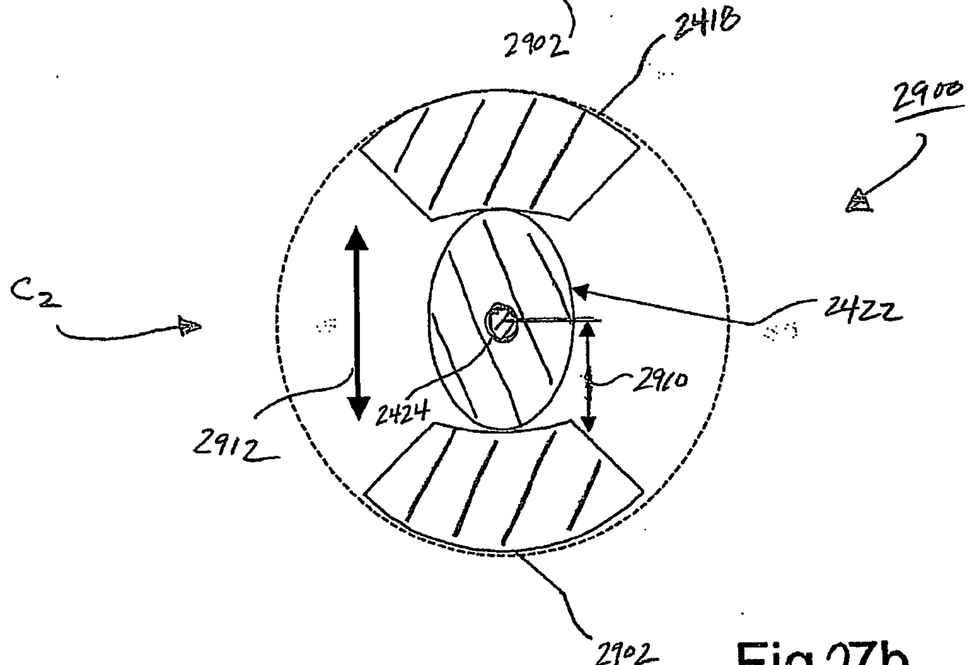


Fig.27b

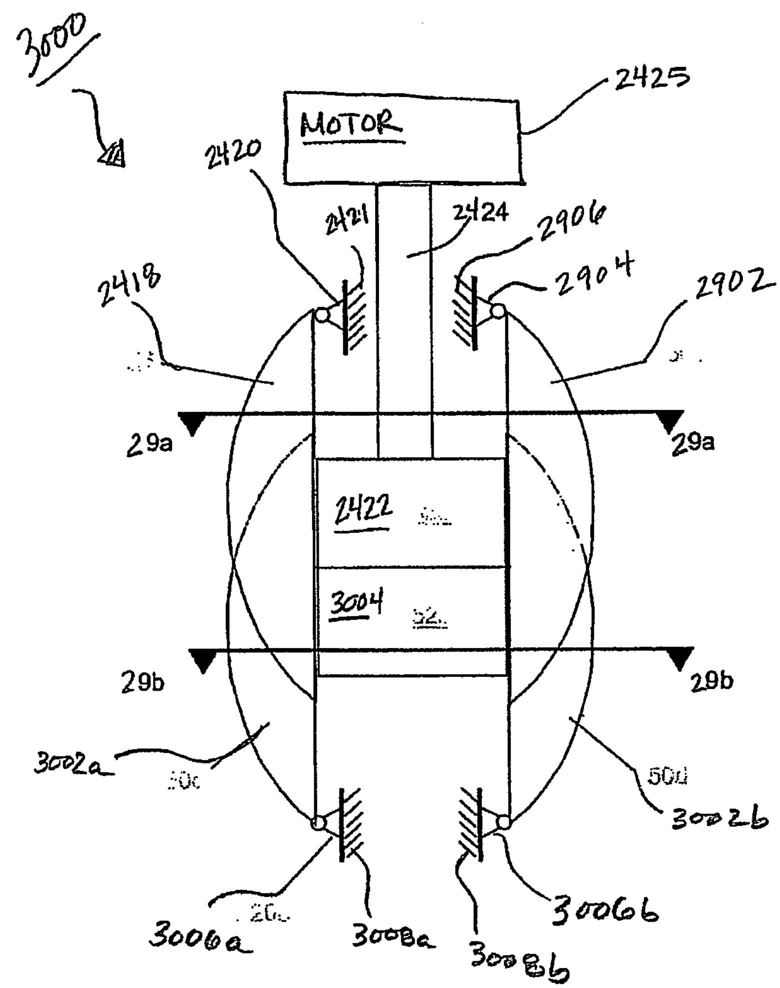
3000
MOTOR
2425
2420
2421
2424
2906
2904
2902
2418
29a
29a
2422
3004
29b
29b
3002a
3002b
3006a
3008a
3008b
3006b

Fig.28

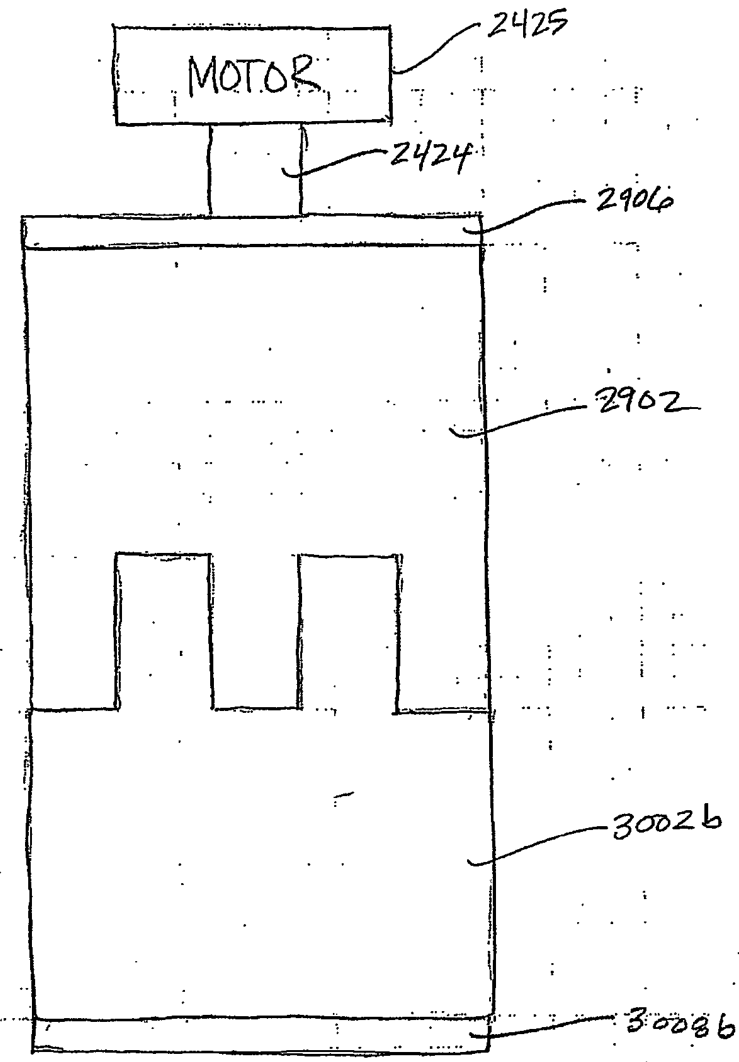


FIGURE 28a

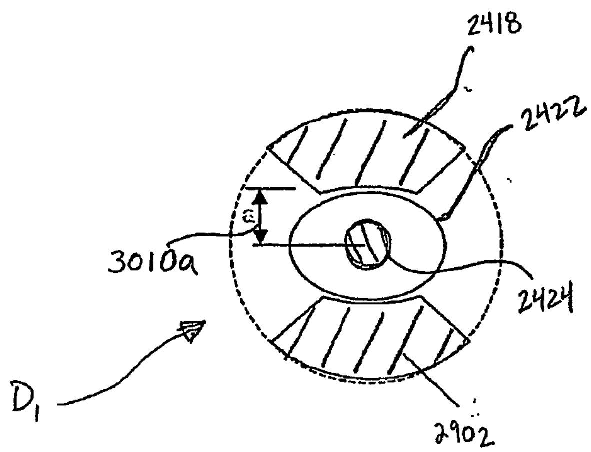


Fig.29a

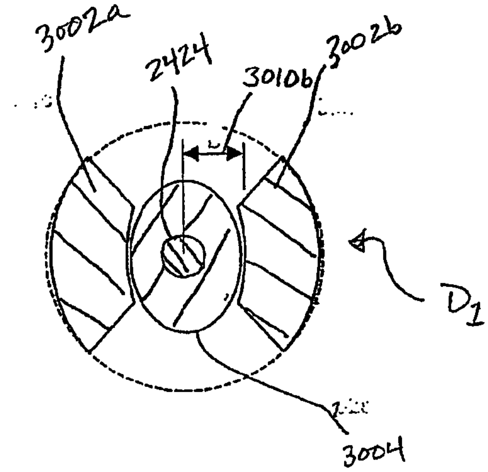


Fig.29b

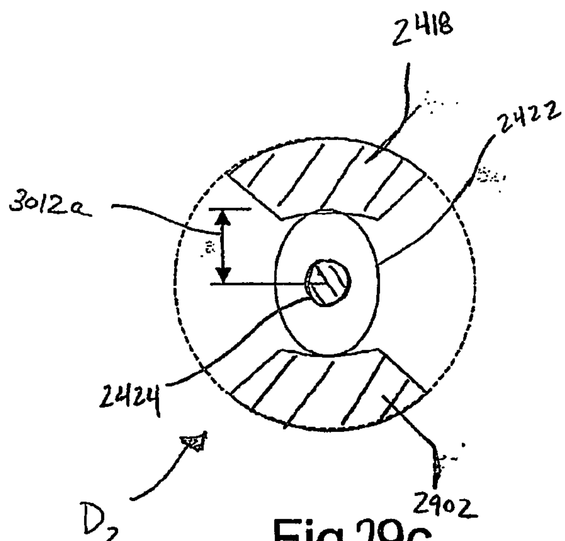


Fig.29c

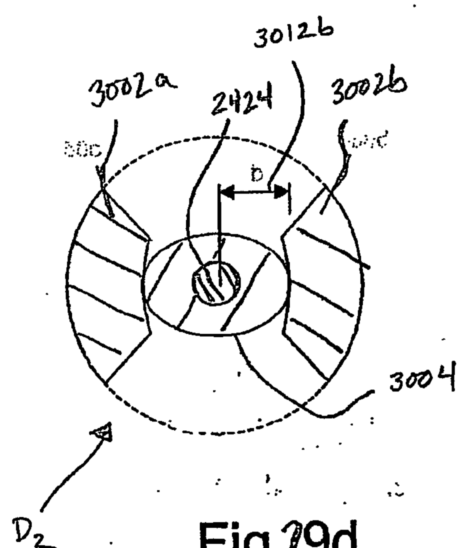


Fig.29d

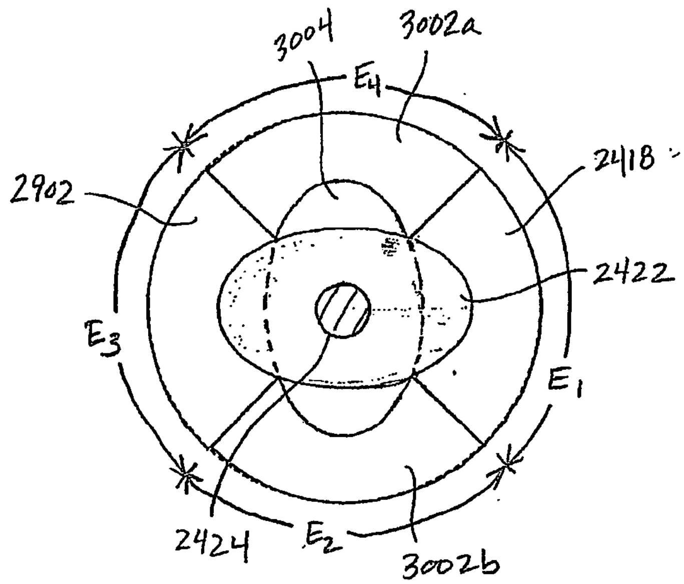


Fig.29e

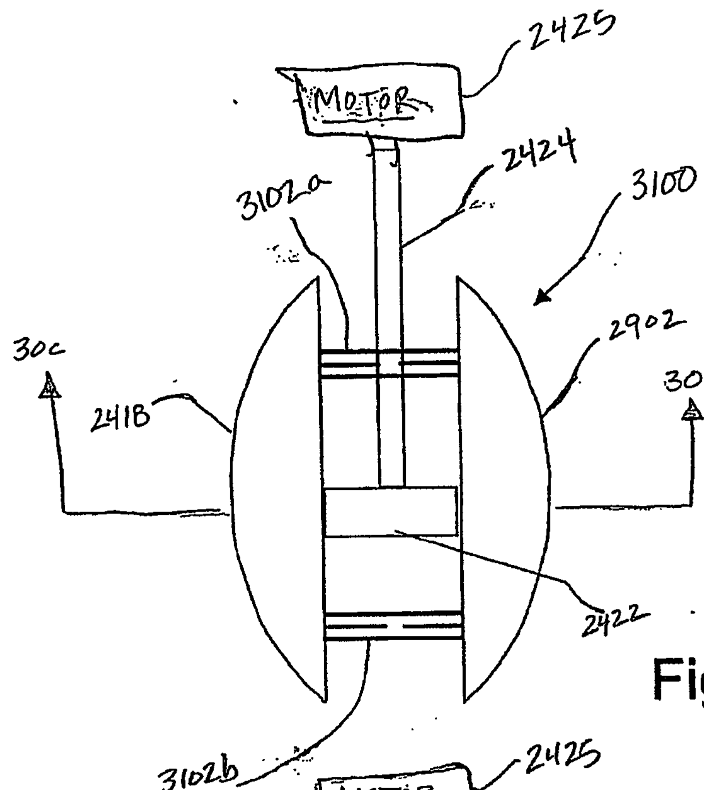


Fig. 30a

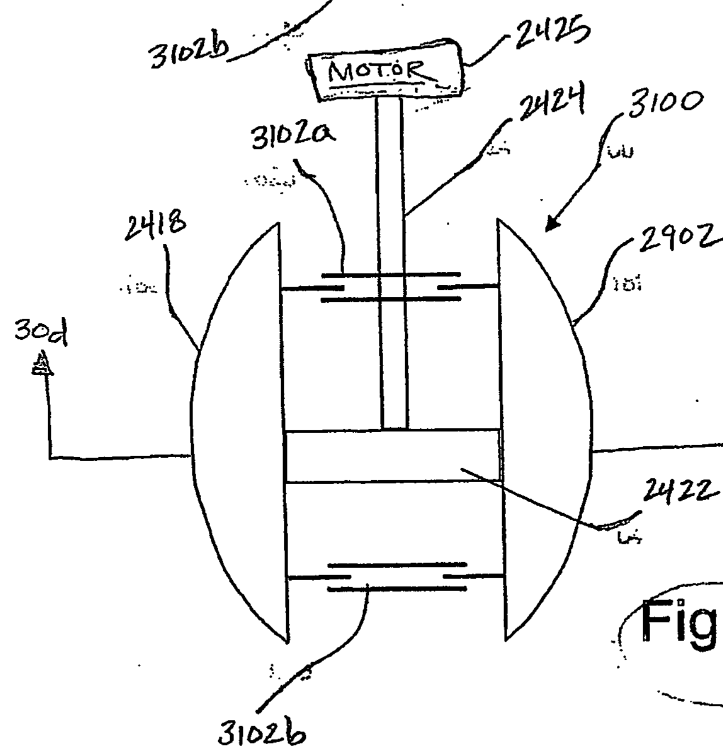


Fig. 30b

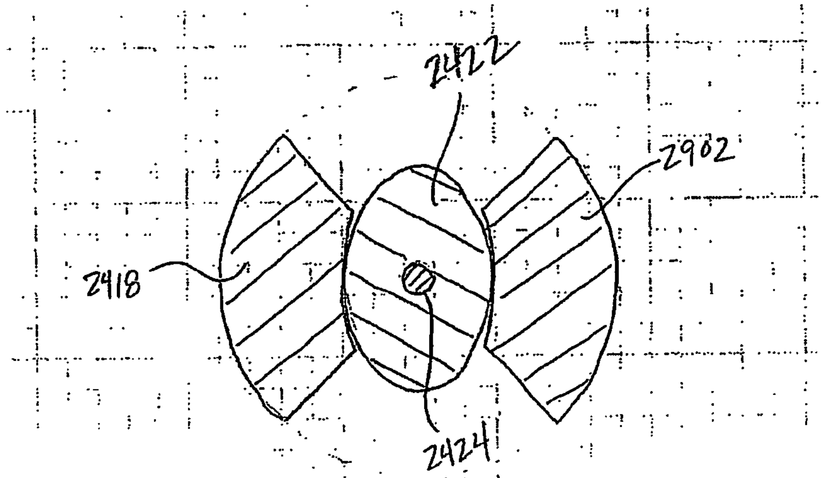


FIGURE 30c

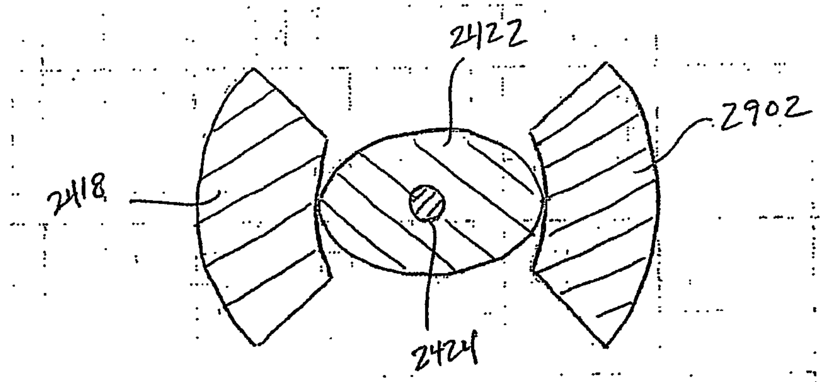


FIGURE 30d

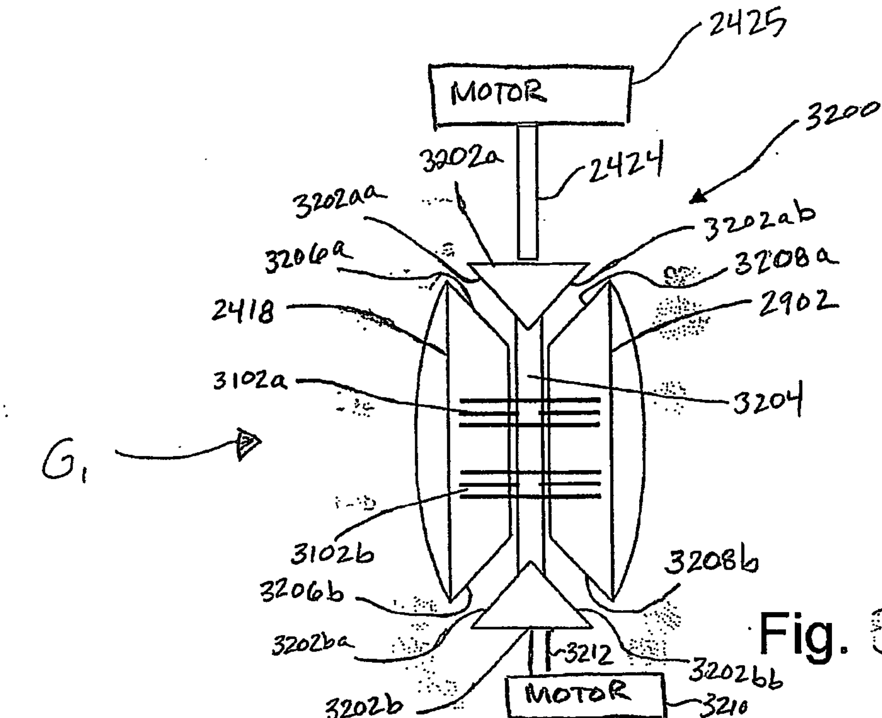


Fig. 31a

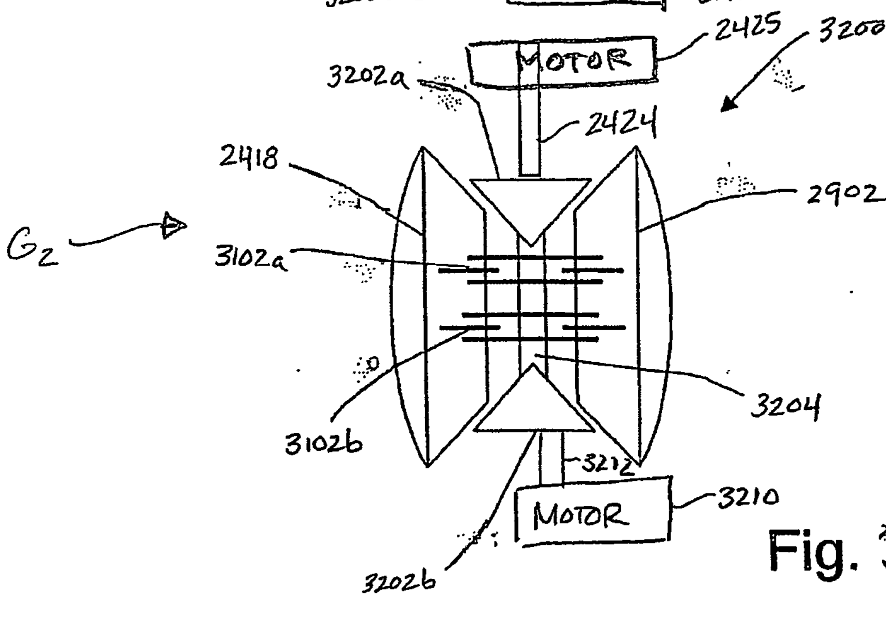


Fig. 31b

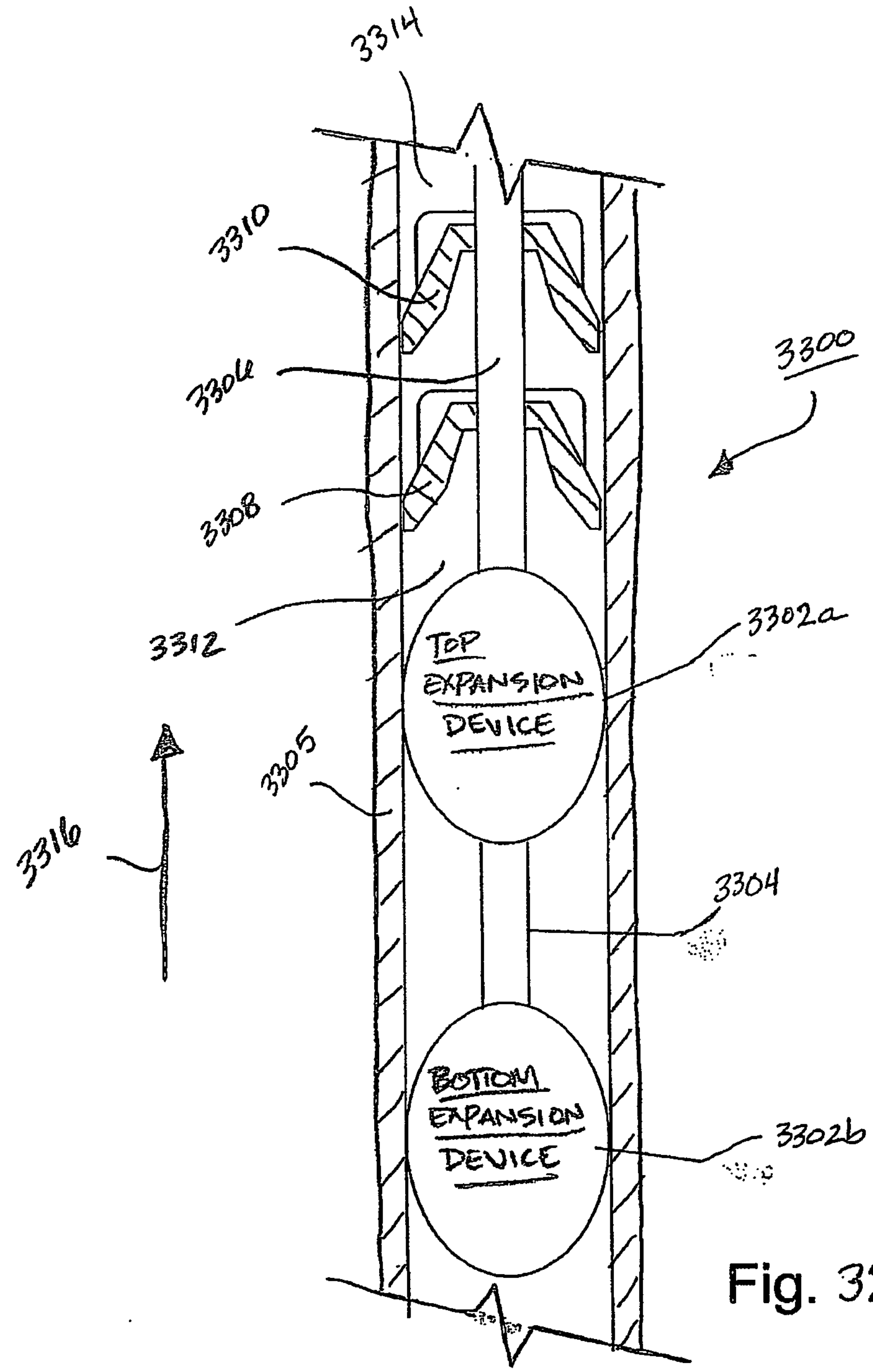
3314
3310
3300
3306
3308
3312
3302a
TOP EXPANSION DEVICE
3305
3316
3304
BOTTOM EXPANSION DEVICE
3302b

Fig. 32

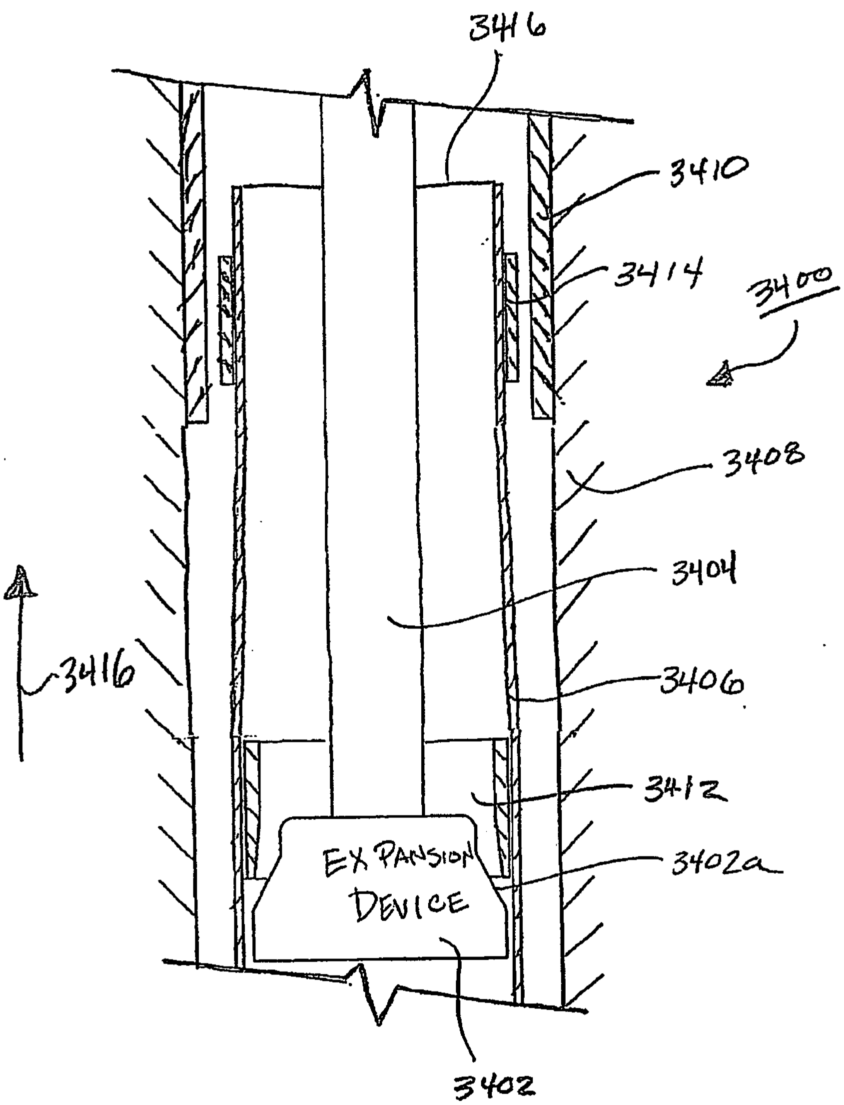
3416
3410
3414
3400
3408
3404
3416
3406
3412
EX PANSION DEVICE
3402a
3402

Fig. 33a

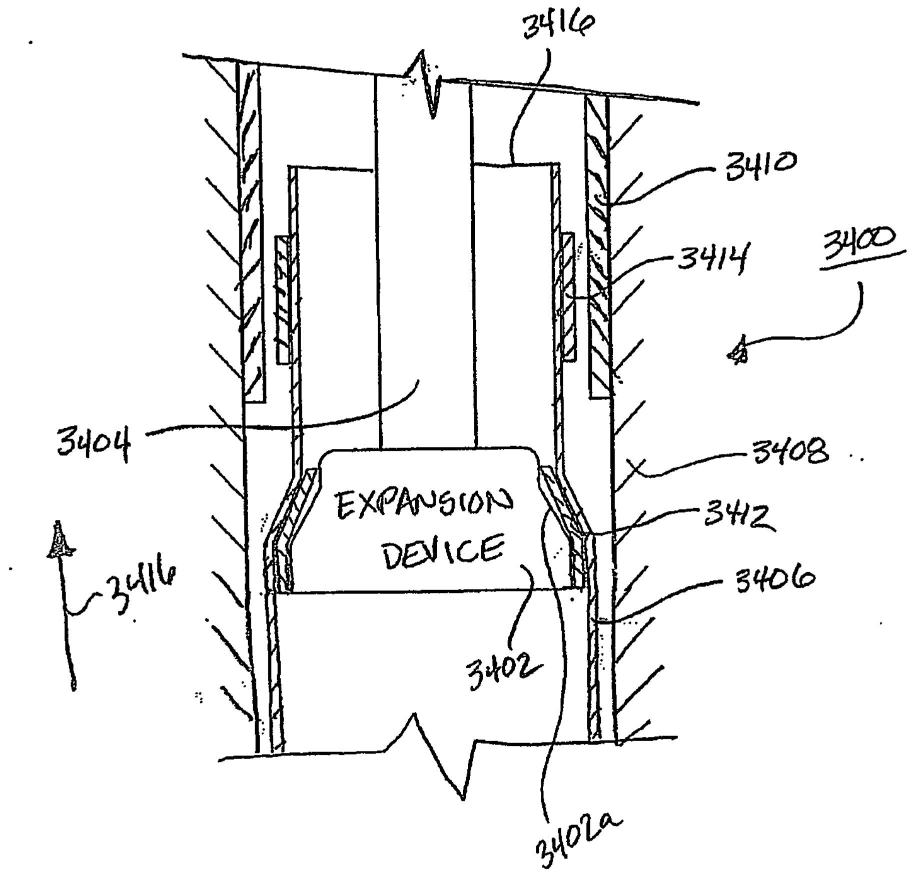
3416
3410
3414
3400
3404
3408
EXPANSION DEVICE
3412
3416
3406
3402
3402a

Fig. 33b

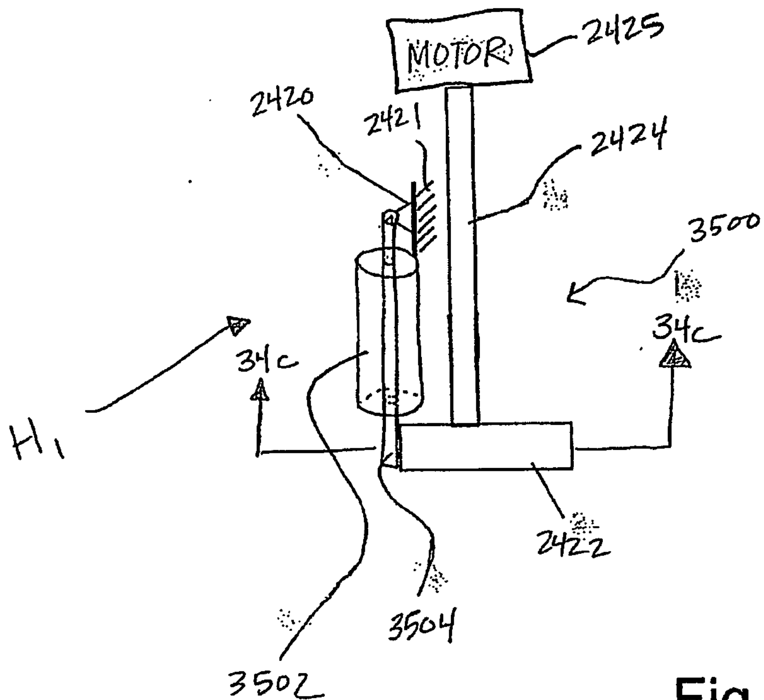


Fig.34a

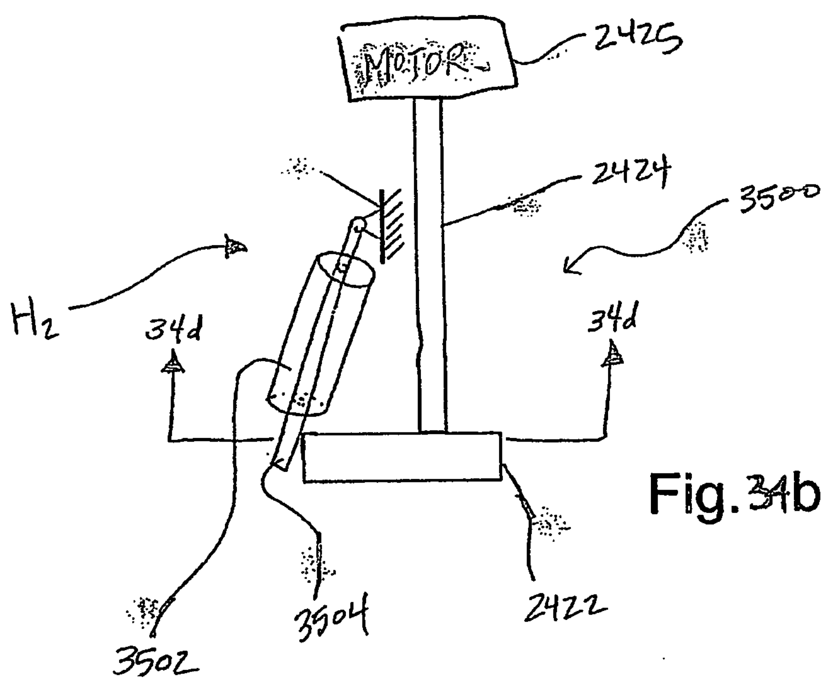


Fig.34b

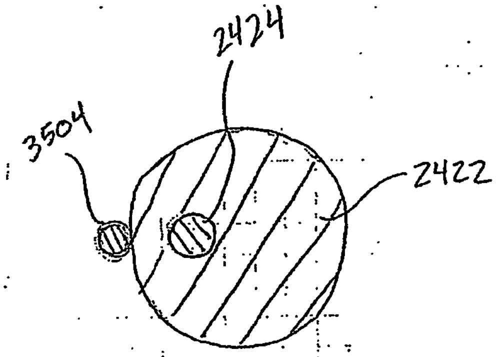


FIGURE 34c

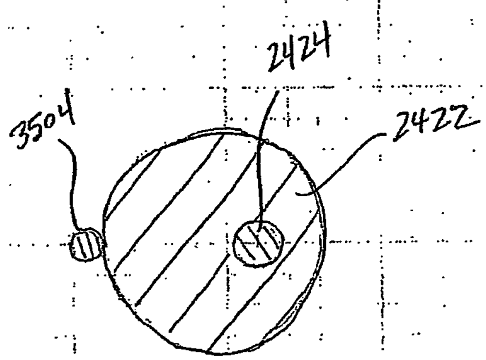


FIGURE 34d

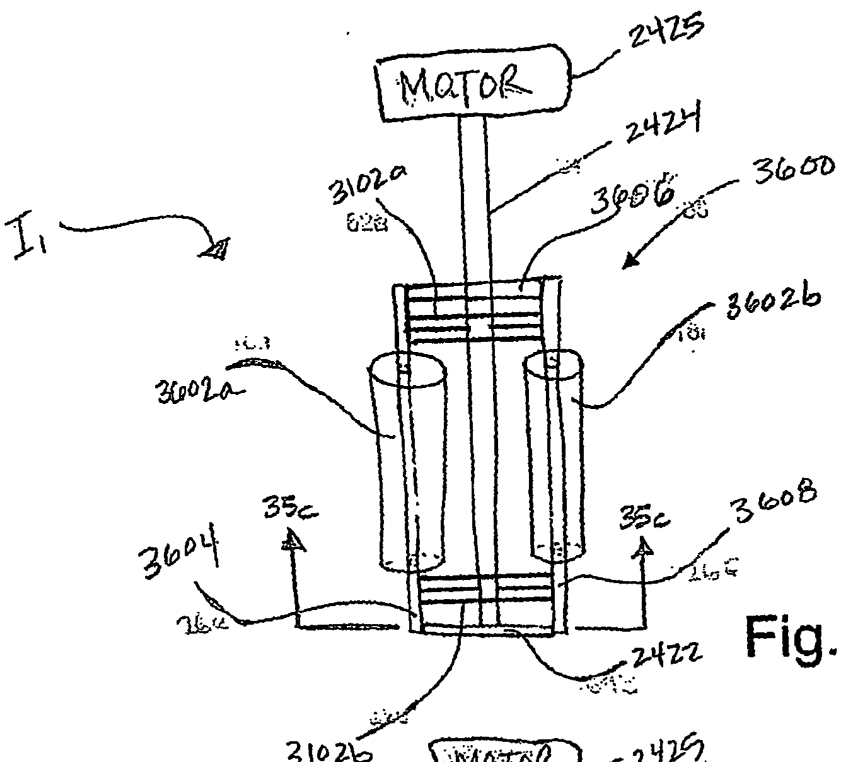


Fig. 35a

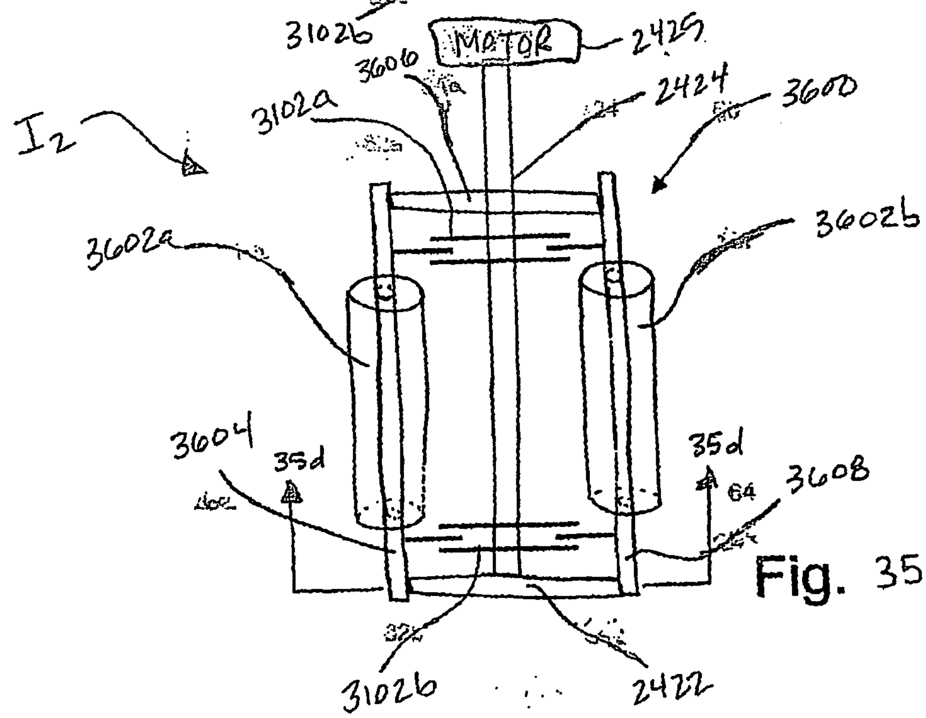


Fig. 35b

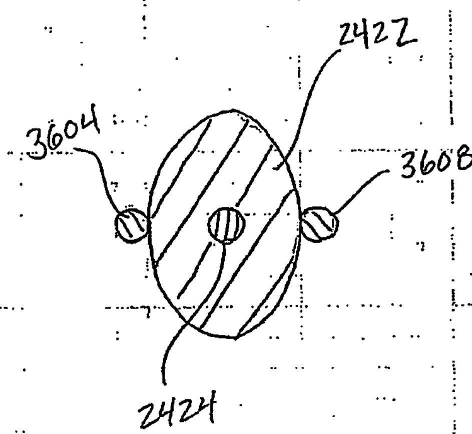


FIGURE 35c

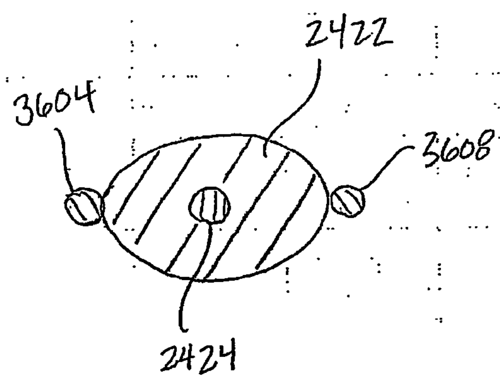


FIGURE 35d

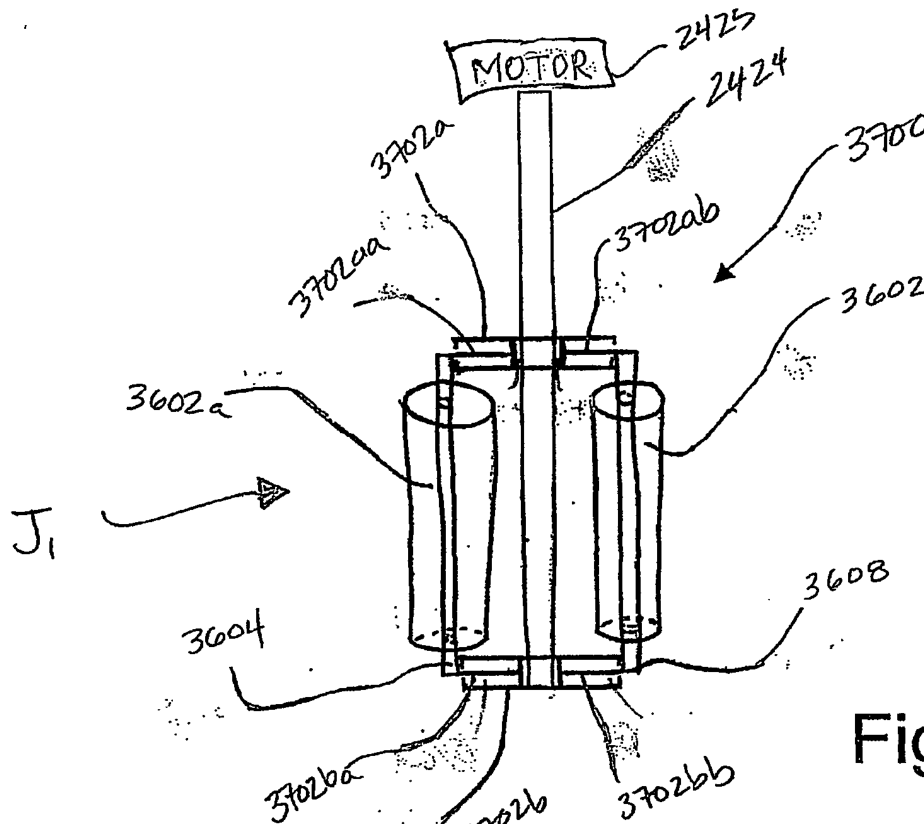


Fig. 36a

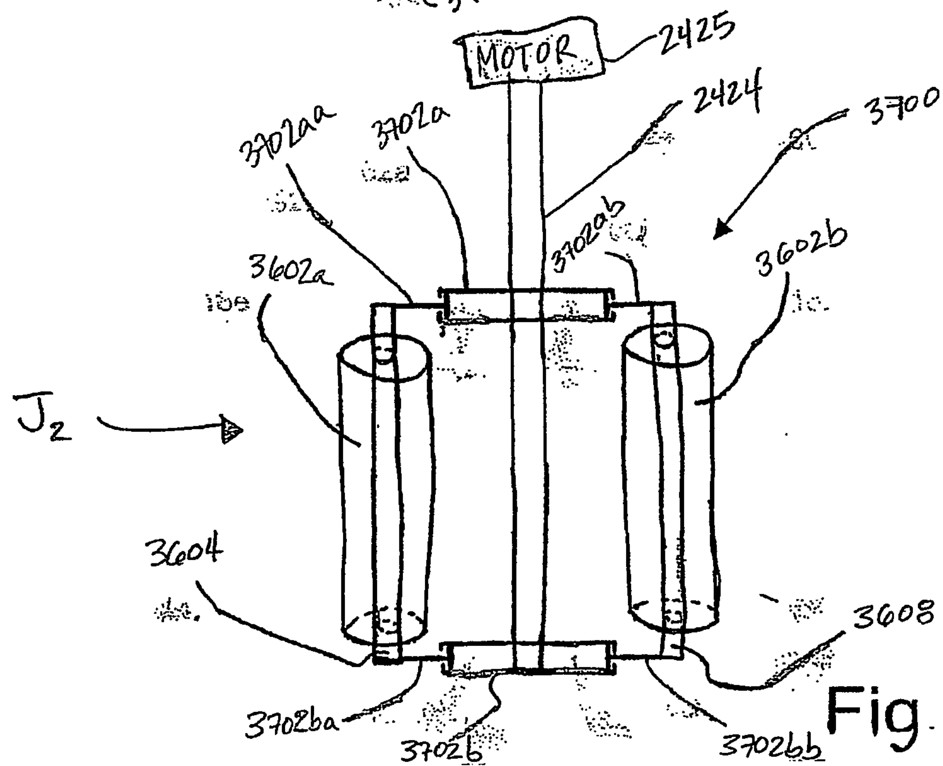


Fig. 36b

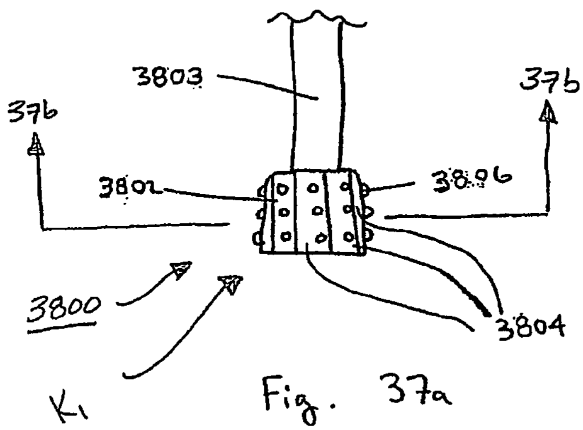


Fig. 37a

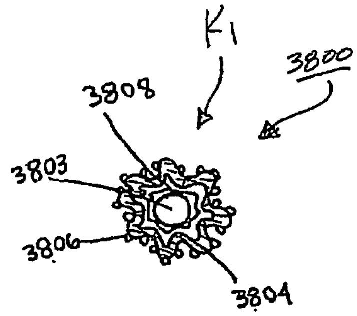


Fig 37b

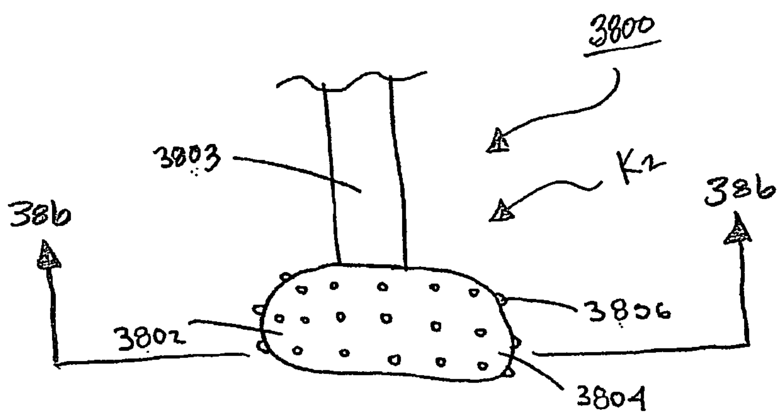


Fig 38a

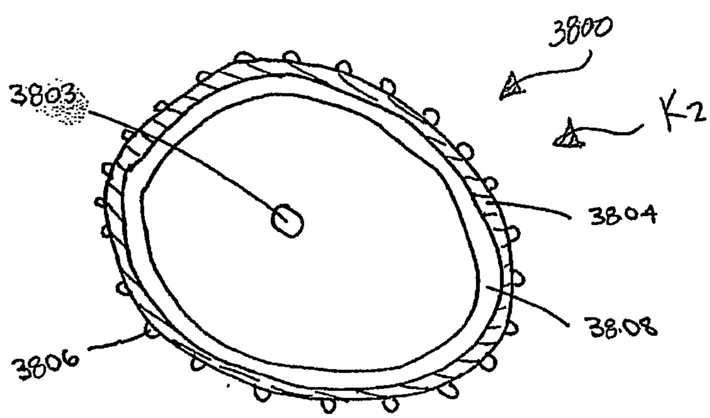


Fig 38b

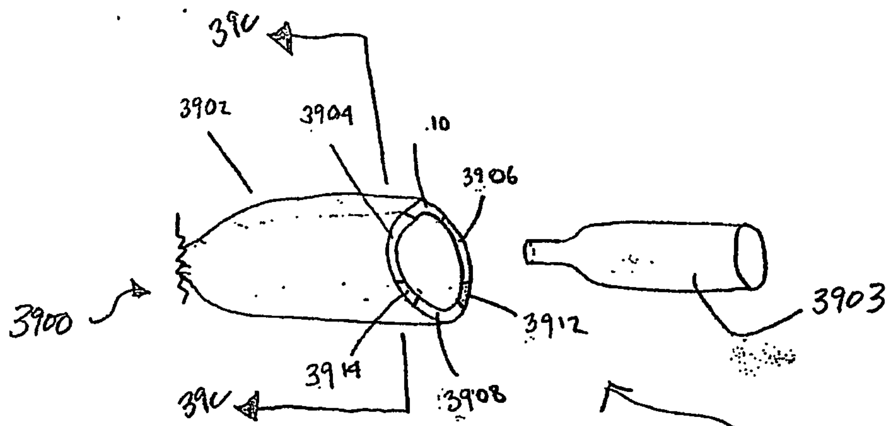


Fig 39b.

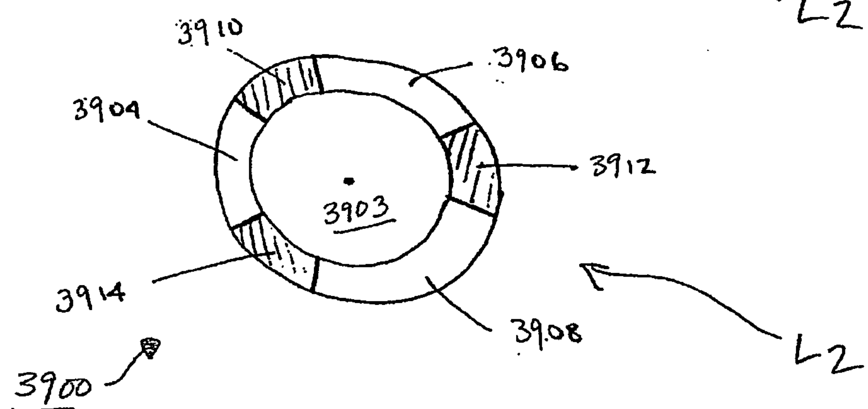


Fig 39c

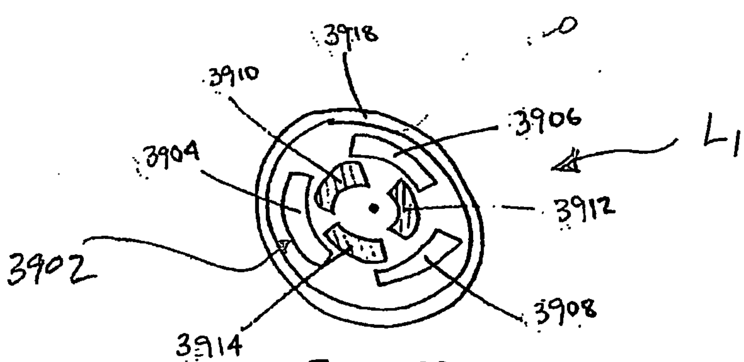


Fig 39a

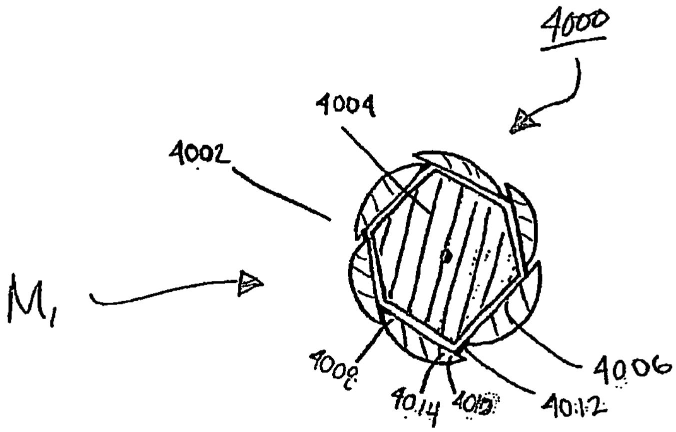


Fig 40a

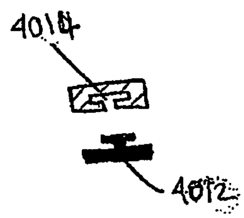


Fig 40c

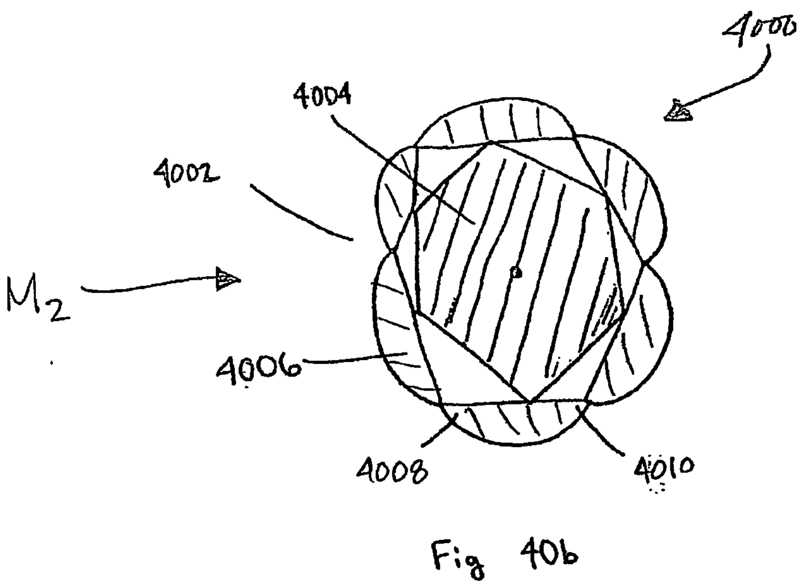


Fig 40b

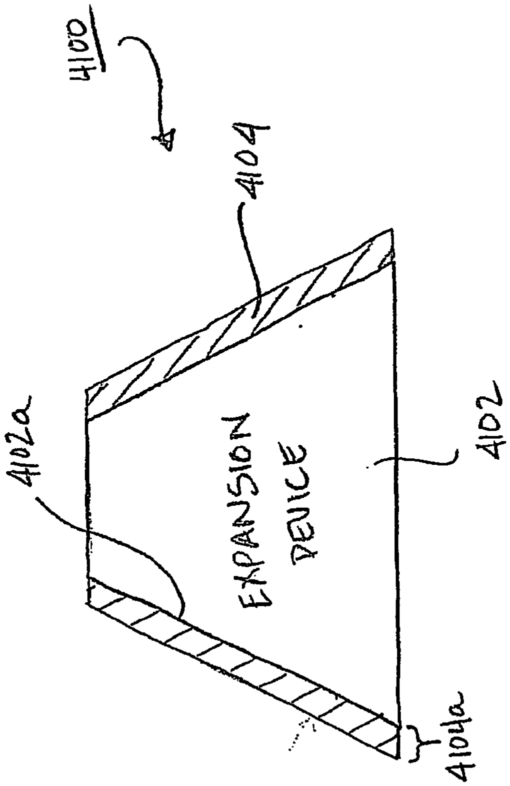


FIGURE 41a

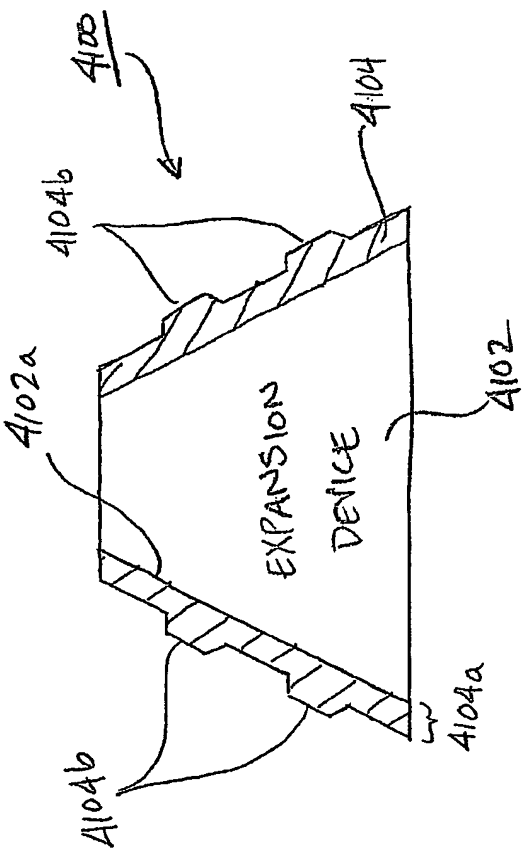


FIGURE 41b

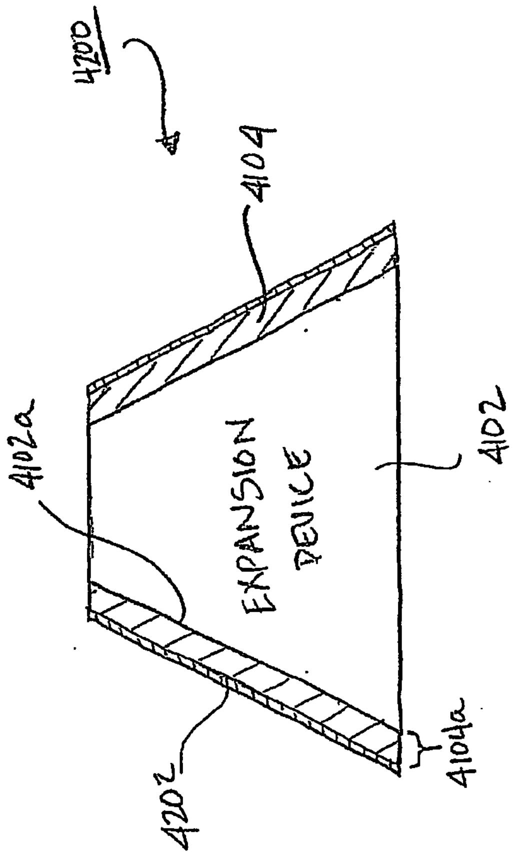


FIGURE 42a

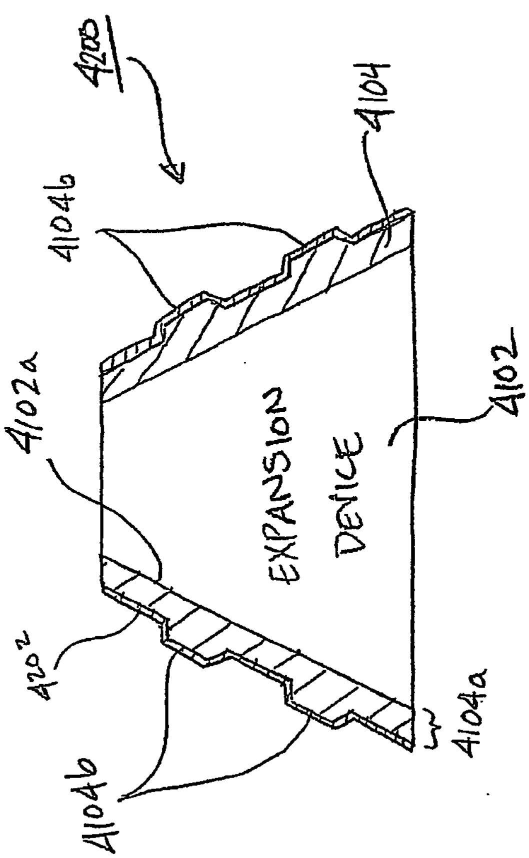
4200
4104b
4104
4102a
EXPANSION
DEVICE
4102
4202
4104b
4104a

FIGURE 42b

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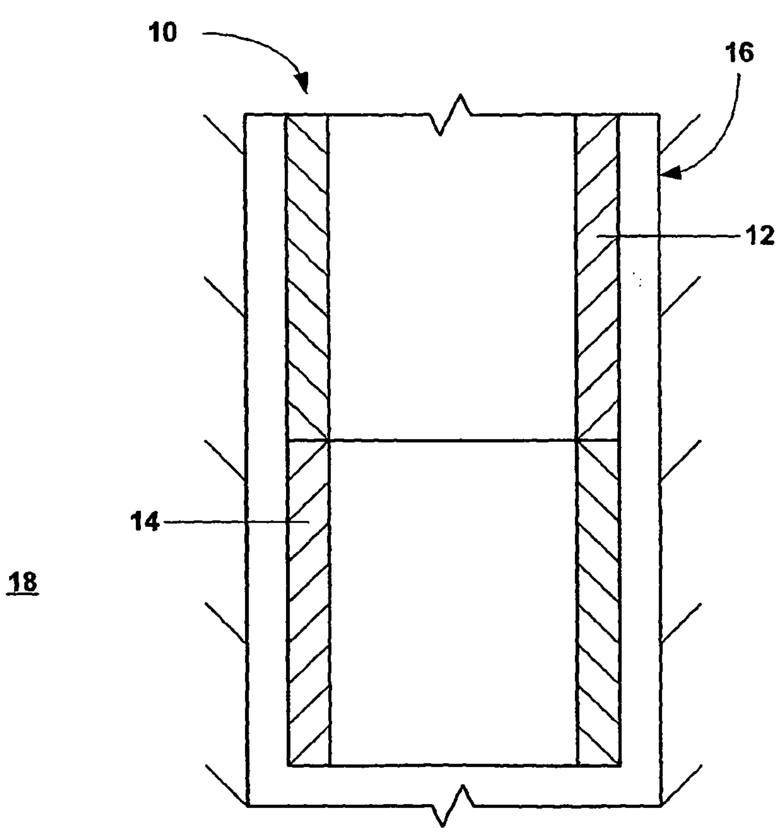
(74) Agents: **MATTIGLY, Todd** et al.; Haynes and Boone, LLP, 901 Main Street, Suite 3100, Dallas, TX 75202 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH,

*[Continued on next page]*

(54) Title: RADIAL EXPANSION SYSTEM




(57) Abstract: A radial expansion system.

WO 2006/102556 A2

GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Declaration under Rule 4.17:**
— *of inventorship (Rule 4.17(iv))*

**Published:**
— *without international search report and to be republished upon receipt of that report*

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# RADIAL EXPANSION SYSTEM

## Cross Reference To Related Applications

[0001] This application claims the benefit of the filing date of US provisional patent application serial number 60/663,883, attorney docket number 25791.337, filed on March 21, 2005, the disclosure which is incorporated herein by reference.

[0002] This application is a continuation-in-part of one or more of the following: (1) U.S. utility patent application serial no. 10/644,101, attorney docket no. 25791.50.06, filed on 8/13/03, which was the National Stage of PCT application US02/04353, filed on 2/14/02, attorney docket no. 25791.50.02, which claims priority from U.S. provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on 2/20/2001; (2) U.S. utility patent application serial no. 10/504361, attorney docket no. 25791.71.09, filed on 1/9/03, which was the National Stage of PCT application US 03/00609, filed on 1/9/03, attorney docket no. 25791.71.02, which claims priority from U.S. provisional patent application serial no. 60/357,372, attorney docket no. 25791.71, filed on 2/15/02; (3) PCT application serial no. PCT/2005/023391, attorney docket no. 25791.299.02, filed on 6/29/05, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/585,370, attorney docket number 25791.299, filed on 7/2/2004; (4) PCT application serial no. PCT/US2005/028669, attorney docket no. 25791.194.02, filed on 8/11/05, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/600,679, attorney docket number 25791.194, filed on 8/11/2004; and (5) U.S. utility patent application serial no. ________, attorney docket no. 25791.308.07, filed on 3/6/06, which was the National Stage of PCT application US2004/028831 filed on 9/7/2004, attorney docket number 25791.308.02, which claims priority from U.S. provisional patent application serial number 60/500,435, attorney docket number 25791.304, filed on 9/5/2003, the disclosures of which are incorporated herein by reference.

[0003] This application is a continuation-in-part of U.S. utility patent application serial no. 10/528498, attorney docket no. 25791.118.08, filed on 3/18/05, which was the National Stage for PCT application serial no. PCT/US03/025667, attorney docket no. 25791.118.02, filed on 8/18/03, which claimed the benefit of the filing date of U.S. provisional patent application serial no. 60/412653, attorney docket 25791.118, filed on 9/20/2002, the disclosures of which are incorporated herein by reference.

[0004] This application is related to the following co-pending applications: (1) U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, which claims priority from provisional application 60/121,702, filed on 2/25/99, (3) U.S. Patent Number 6,823,937, which was filed as U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, which claims priority from provisional application 60/119,611, filed on 2/11/99, (4) U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority

from provisional application 60/108,558, filed on 11/16/98, (5) U.S. patent application serial no. 10/169,434, attorney docket no. 25791.10.04, filed on 7/1/02, which claims priority from provisional application 60/183,546, filed on 2/18/00, (6) U.S. patent no. 6,640,903 which was filed as U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (7) U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (8) U.S. patent number 6,575,240, which was filed as patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, which claims priority from provisional application 60/121,907, filed on 2/26/99, (9) U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (10) U.S. patent application serial no. 09/981,916, attorney docket no. 25791.18, filed on 10/18/01 as a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (11) U.S. patent number 6,604,763, which was filed as application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, which claims priority from provisional application 60/131,106, filed on 4/26/99, (12) U.S. patent application serial no. 10/030,593, attorney docket no. 25791.25.08, filed on 1/8/02, which claims priority from provisional application 60/146,203, filed on 7/29/99, (13) U.S. provisional patent application serial no. 60/143,039, attorney docket no. 25791.26, filed on 7/9/99, (14) U.S. patent application serial no. 10/111,982, attorney docket no. 25791.27.08, filed on 4/30/02, which claims priority from provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (15) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (16) U.S. provisional patent application serial no. 60/438,828, attorney docket no. 25791.31, filed on 1/9/03, (17) U.S. patent number 6,564,875, which was filed as application serial no. 09/679,907, attorney docket no. 25791.34.02, on 10/5/00, which claims priority from provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (18) U.S. patent application serial no. 10/089,419, filed on 3/27/02, attorney docket no. 25791.36.03, which claims priority from provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (19) U.S. patent application serial no. 09/679,906, filed on 10/5/00, attorney docket no. 25791.37.02, which claims priority from provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (20) U.S. patent application serial no. 10/303,992, filed on 11/22/02, attorney docket no. 25791.38.07, which claims priority from provisional patent application serial no. 60/212,359, attorney docket no. 25791.38, filed on 6/19/2000, (21) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (22) U.S. provisional patent application serial no. 60/455,051, attorney docket no. 25791.40, filed on 3/14/03, (23) PCT application US02/2477, filed on 6/26/02, attorney docket no. 25791.44.02, which

claims priority from U.S. provisional patent application serial no. 60/303,711, attorney docket no. 25791.44, filed on 7/6/01, (24) U.S. patent application serial no. 10/311,412, filed on 12/12/02, attorney docket no. 25791.45.07, which claims priority from provisional patent application serial no. 60/221,443, attorney docket no. 25791.45, filed on 7/28/2000, (25) U.S. patent application serial no. 10/, filed on 12/18/02, attorney docket no. 25791.46.07, which claims priority from provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (26) U.S. patent application serial no. 10/322,947, filed on 1/22/03, attorney docket no. 25791.47.03, which claims priority from provisional patent application serial no. 60/233,638, attorney docket no. 25791.47, filed on 9/18/2000, (27) U.S. patent application serial no. 10/406,648, filed on 3/31/03, attorney docket no. 25791.48.06, which claims priority from provisional patent application serial no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, (28) PCT application US02/04353, filed on 2/14/02, attorney docket no. 25791.50.02, which claims priority from U.S. provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on 2/20/2001, (29) U.S. patent application serial no. 10/465,835, filed on 6/13/03, attorney docket no. 25791.51.06, which claims priority from provisional patent application serial no. 60/262,434, attorney docket no. 25791.51, filed on 1/17/2001, (30) U.S. patent application serial no. 10/465,831, filed on 6/13/03, attorney docket no. 25791.52.06, which claims priority from U.S. provisional patent application serial no. 60/259,486, attorney docket no. 25791.52, filed on 1/3/2001, (31) U.S. provisional patent application serial no. 60/452,303, filed on 3/5/03, attorney docket no. 25791.53, (32) U.S. patent number 6,470,966, which was filed as patent application serial number 09/850,093, filed on 5/7/01, attorney docket no. 25791.55, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (33) U.S. patent number 6,561,227, which was filed as patent application serial number 09/852,026 , filed on 5/9/01, attorney docket no. 25791.56, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (34) U.S. patent application serial number 09/852,027, filed on 5/9/01, attorney docket no. 25791.57, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (35) PCT Application US02/25608, attorney docket no. 25791.58.02, filed on 8/13/02, which claims priority from provisional application 60/318,021, filed on 9/7/01, attorney docket no. 25791.58, (36) PCT Application US02/24399, attorney docket no. 25791.59.02, filed on 8/1/02, which claims priority from U.S. provisional patent application serial no. 60/313,453, attorney docket no. 25791.59, filed on 8/20/2001, (37) PCT Application US02/29856, attorney docket no. 25791.60.02, filed on 9/19/02, which claims priority from U.S. provisional patent application serial no. 60/326,886, attorney docket no. 25791.60, filed on 10/3/2001, (38) PCT Application US02/20256, attorney docket no. 25791.61.02, filed on 6/26/02, which claims priority from

U.S. provisional patent application serial no. 60/303,740, attorney docket no. 25791.61, filed on 7/6/2001, (39) U.S. patent application serial no. 09/962,469, filed on 9/25/01, attorney docket no. 25791.62, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99, (40) U.S. patent application serial no. 09/962,470, filed on 9/25/01, attorney docket no. 25791.63, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99, (41) U.S. patent application serial no. 09/962,471, filed on 9/25/01, attorney docket no. 25791.64, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99, (42) U.S. patent application serial no. 09/962,467, filed on 9/25/01, attorney docket no. 25791.65, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99, (43) U.S. patent application serial no. 09/962,468, filed on 9/25/01, attorney docket no. 25791.66, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, (now U.S. Patent 6,640,903 which issued 11/4/2003), which claims priority from provisional application 60/124,042, filed on 3/11/99, (44) PCT application US 02/25727, filed on 8/14/02, attorney docket no. 25791.67.03, which claims priority from U.S. provisional patent application serial no. 60/317,985, attorney docket no. 25791.67, filed on 9/6/2001, and U.S. provisional patent application serial no. 60/318,386, attorney docket no. 25791.67.02, filed on 9/10/2001, (45) PCT application US 02/39425, filed on 12/10/02, attorney docket no. 25791.68.02, which claims priority from U.S. provisional patent application serial no. 60/343,674 , attorney docket no. 25791.68, filed on 12/27/2001, (46) U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, (now U.S. Patent 6,634,431 which issued 10/21/2003), which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (47) U.S. utility patent application serial no. 10/516,467, attorney docket no. 25791.70, filed on 12/10/01, which is a continuation application of U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, (now U.S. Patent 6,634,431 which issued 10/21/2003), which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (48) PCT application US 03/00609, filed on 1/9/03, attorney docket no. 25791.71.02, which claims priority from U.S. provisional patent application serial no. 60/357,372 , attorney docket no. 25791.71, filed on 2/15/02, (49) U.S. patent application serial no. 10/074,703,

attorney docket no. 25791.74, filed on 2/12/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (50) U.S. patent application serial no. 10/074,244, attorney docket no. 25791.75, filed on 2/12/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (51) U.S. patent application serial no. 10/076,660, attorney docket no. 25791.76, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (52) U.S. patent application serial no. 10/076,661, attorney docket no. 25791.77, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (53) U.S. patent application serial no. 10/076,659, attorney docket no. 25791.78, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (54) U.S. patent application serial no. 10/078,928, attorney docket no. 25791.79, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (55) U.S. patent application serial no. 10/078,922, attorney docket no. 25791.80, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (56) U.S. patent application serial no. 10/078,921, attorney docket no. 25791.81, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (57) U.S. patent application serial no. 10/261,928, attorney docket no. 25791.82, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (58) U.S. patent application serial no. 10/079,276, attorney docket no. 25791.83, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (59) U.S. patent application serial no. 10/262,009, attorney docket no. 25791.84, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (60) U.S. patent

application serial no. 10/092,481, attorney docket no. 25791.85, filed on 3/7/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (61) U.S. patent application serial no. 10/261,926, attorney docket no. 25791.86, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (62) PCT application US 02/36157, filed on 11/12/02, attorney docket no. 25791.87.02, which claims priority from U.S. provisional patent application serial no. 60/338,996, attorney docket no. 25791.87, filed on 11/12/01, (63) PCT application US 02/36267, filed on 11/12/02, attorney docket no. 25791.88.02, which claims priority from U.S. provisional patent application serial no. 60/339,013, attorney docket no. 25791.88, filed on 11/12/01, (64) PCT application US 03/11765, filed on 4/16/03, attorney docket no. 25791.89.02, which claims priority from U.S. provisional patent application serial no. 60/383,917, attorney docket no. 25791.89, filed on 5/29/02, (65) PCT application US 03/15020, filed on 5/12/03, attorney docket no. 25791.90.02, which claims priority from U.S. provisional patent application serial no. 60/391,703, attorney docket no. 25791.90, filed on 6/26/02, (66) PCT application US 02/39418, filed on 12/10/02, attorney docket no. 25791.92.02, which claims priority from U.S. provisional patent application serial no. 60/346,309, attorney docket no. 25791.92, filed on 1/7/02, (67) PCT application US 03/06544, filed on 3/4/03, attorney docket no. 25791.93.02, which claims priority from U.S. provisional patent application serial no. 60/372,048, attorney docket no. 25791.93, filed on 4/12/02, (68) U.S. patent application serial no. 10/331,718, attorney docket no. 25791.94, filed on 12/30/02, which is a divisional U.S. patent application serial no. 09/679,906, filed on 10/5/00, attorney docket no. 25791.37.02, which claims priority from provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (69) PCT application US 03/04837, filed on 2/29/03, attorney docket no. 25791.95.02, which claims priority from U.S. provisional patent application serial no. 60/363,829, attorney docket no. 25791.95, filed on 3/13/02, (70) U.S. patent application serial no. 10/261,927, attorney docket no. 25791.97, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (71) U.S. patent application serial no. 10/262,008, attorney docket no. 25791.98, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (72) U.S. patent application serial no. 10/261,925, attorney docket no. 25791.99, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (73) U.S. patent application serial no. 10/199,524, attorney docket no. 25791.100, filed on 7/19/02, which is a continuation of U.S. Patent Number

6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (74) PCT application US 03/10144, filed on 3/28/03, attorney docket no. 25791.101.02, which claims priority from U.S. provisional patent application serial no. 60/372,632, attorney docket no. 25791.101, filed on 4/15/02, (75) U.S. provisional patent application serial no. 60/412,542, attorney docket no. 25791.102, filed on 9/20/02, (76) PCT application US 03/14153, filed on 5/6/03, attorney docket no. 25791.104.02, which claims priority from U.S. provisional patent application serial no. 60/380,147, attorney docket no. 25791.104, filed on 5/6/02, (77) PCT application US 03/19993, filed on 6/24/03, attorney docket no. 25791.106.02, which claims priority from U.S. provisional patent application serial no. 60/397,284, attorney docket no. 25791.106, filed on 7/19/02, (78) PCT application US 03/13787, filed on 5/5/03, attorney docket no. 25791.107.02, which claims priority from U.S. provisional patent application serial no. 60/387,486, attorney docket no. 25791.107, filed on 6/10/02, (79) PCT application US 03/18530, filed on 6/11/03, attorney docket no. 25791.108.02, which claims priority from U.S. provisional patent application serial no. 60/387,961, attorney docket no. 25791.108, filed on 6/12/02, (80) PCT application US 03/20694, filed on 7/1/03, attorney docket no. 25791.110.02, which claims priority from U.S. provisional patent application serial no. 60/398,061, attorney docket no. 25791.110, filed on 7/24/02, (81) PCT application US 03/20870, filed on 7/2/03, attorney docket no. 25791.111.02, which claims priority from U.S. provisional patent application serial no. 60/399,240, attorney docket no. 25791.111, filed on 7/29/02, (82) U.S. provisional patent application serial no. 60/412,487, attorney docket no. 25791.112, filed on 9/20/02, (83) U.S. provisional patent application serial no. 60/412,488, attorney docket no. 25791.114, filed on 9/20/02, (84) U.S. patent application serial no. 10/280,356, attorney docket no. 25791.115, filed on 10/25/02, which is a continuation of U.S. patent number 6,470,966, which was filed as patent application serial number 09/850,093, filed on 5/7/01, attorney docket no. 25791.55, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (85) U.S. provisional patent application serial no. 60/412,177, attorney docket no. 25791.117, filed on 9/20/02, (86) U.S. provisional patent application serial no. 60/412,653, attorney docket no. 25791.118, filed on 9/20/02, (87) U.S. provisional patent application serial no. 60/405,610, attorney docket no. 25791.119, filed on 8/23/02, (88) U.S. provisional patent application serial no. 60/405,394, attorney docket no. 25791.120, filed on 8/23/02, (89) U.S. provisional patent application serial no. 60/412,544, attorney docket no. 25791.121, filed on 9/20/02, (90) PCT application US 03/24779, filed on 8/8/03, attorney docket no. 25791.125.02, which claims priority from U.S. provisional patent application serial no. 60/407,442, attorney docket no. 25791.125, filed on 8/30/02, (91) U.S. provisional patent application serial no. 60/423,363, attorney docket no. 25791.126, filed on 12/10/02, (92) U.S. provisional patent application serial no. 60/412,196, attorney docket no. 25791.127, filed on 9/20/02, (93) U.S. provisional patent application serial no. 60/412,187, attorney docket no. 25791.128, filed on 9/20/02, (94) U.S.

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## Background of the Invention

[0005] This invention relates generally to oil and gas exploration, and in particular to forming and repairing wellbore casings to facilitate oil and gas exploration.

## Brief Description of the Drawings

[0001] Fig. 1 is a fragmentary cross sectional view of an exemplary embodiment of an expandable tubular member positioned within a preexisting structure.

[0002] Fig. 2 is a fragmentary cross sectional view of the expandable tubular member of Fig. 1 after positioning an expansion device within the expandable tubular member.

[0003] Fig. 3 is a fragmentary cross sectional view of the expandable tubular member of Fig. 2 after operating the expansion device within the expandable tubular member to radially expand and plastically deform a portion of the expandable tubular member.

[0004] Fig. 4 is a fragmentary cross sectional view of the expandable tubular member of Fig. 3 after operating the expansion device within the expandable tubular member to radially expand and plastically deform another portion of the expandable tubular member.

[0005] Fig. 5 is a graphical illustration of exemplary embodiments of the stress/strain curves for several portions of the expandable tubular member of Figs. 1-4.

[0006] Fig. 6 is a graphical illustration of the an exemplary embodiment of the yield strength vs. ductility curve for at least a portion of the expandable tubular member of Figs. 1-4.

[0007] Fig. 7 is a fragmentary cross sectional illustration of an embodiment of a series of overlapping expandable tubular members.

[0008] Fig. 8 is a fragmentary cross sectional view of an exemplary embodiment of an expandable tubular member positioned within a preexisting structure.

[0009] Fig. 9 is a fragmentary cross sectional view of the expandable tubular member of Fig. 8 after positioning an expansion device within the expandable tubular member.

[00010] Fig. 10 is a fragmentary cross sectional view of the expandable tubular member of Fig. 9 after operating the expansion device within the expandable tubular member to radially expand and plastically deform a portion of the expandable tubular member.

[00011] Fig. 11 is a fragmentary cross sectional view of the expandable tubular member of Fig. 10 after operating the expansion device within the expandable tubular member to radially expand and plastically deform another portion of the expandable tubular member.

[00012] Fig. 12 is a graphical illustration of exemplary embodiments of the stress/strain curves for several portions of the expandable tubular member of Figs. 8-11.

[00013] Fig. 13 is a graphical illustration of an exemplary embodiment of the yield strength vs. ductility curve for at least a portion of the expandable tubular member of Figs. 8-11.

[00014] Fig. 14 is a fragmentary cross sectional view of an exemplary embodiment of an expandable tubular member positioned within a preexisting structure.

[00015] Fig. 15 is a fragmentary cross sectional view of the expandable tubular member of Fig. 14 after positioning an expansion device within the expandable tubular member.

[00016] Fig. 16 is a fragmentary cross sectional view of the expandable tubular member of Fig. 15 after operating the expansion device within the expandable tubular member to radially expand and plastically deform a portion of the expandable tubular member.

[00017] Fig. 17 is a fragmentary cross sectional view of the expandable tubular member of Fig. 16 after operating the expansion device within the expandable tubular member to radially expand and plastically deform another portion of the expandable tubular member.

[00018] Fig. 18 is a flow chart illustration of an exemplary embodiment of a method of processing an expandable tubular member.

[00019] Fig. 19 is a graphical illustration of the an exemplary embodiment of the yield strength vs. ductility curve for at least a portion of the expandable tubular member during the operation of the method of Fig. 18.

[00020] Fig. 20 is a graphical illustration of stress/strain curves for an exemplary embodiment of an expandable tubular member.

[00021] Fig. 21 is a graphical illustration of stress/strain curves for an exemplary embodiment of an expandable tubular member.

[00022] Fig. 22 is a fragmentary cross-sectional view illustrating an embodiment of the radial expansion and plastic deformation of a portion of a first tubular member having an internally threaded connection at an end portion, an embodiment of a tubular sleeve supported by the end portion of the first tubular member, and a second tubular member having an externally threaded portion coupled to the internally threaded portion of the first tubular member and engaged by a flange of the sleeve. The sleeve includes the flange at one end for increasing axial compression loading.

[00023] Fig. 23 is a fragmentary cross-sectional view illustrating an embodiment of the radial expansion and plastic deformation of a portion of a first tubular member having an internally threaded connection at an end portion, a second tubular member having an externally threaded portion coupled to the internally threaded portion of the first tubular member, and an embodiment of a tubular sleeve supported by the end portion of both tubular members. The sleeve includes flanges at opposite ends for increasing axial tension loading.

[00024] Fig. 24 is a fragmentary cross-sectional illustration of the radial expansion and plastic deformation of a portion of a first tubular member having an internally threaded connection at an end

portion, a second tubular member having an externally threaded portion coupled to the internally threaded portion of the first tubular member, and an embodiment of a tubular sleeve supported by the end portion of both tubular members. The sleeve includes flanges at opposite ends for increasing axial compression/tension loading.

[00025] Fig. 25 is a fragmentary cross-sectional illustration of the radial expansion and plastic deformation of a portion of a first tubular member having an internally threaded connection at an end portion, a second tubular member having an externally threaded portion coupled to the internally threaded portion of the first tubular member, and an embodiment of a tubular sleeve supported by the end portion of both tubular members. The sleeve includes flanges at opposite ends having sacrificial material thereon.

[00026] Fig. 26 is a fragmentary cross-sectional illustration of the radial expansion and plastic deformation of a portion of a first tubular member having an internally threaded connection at an end portion, a second tubular member having an externally threaded portion coupled to the internally threaded portion of the first tubular member, and an embodiment of a tubular sleeve supported by the end portion of both tubular members. The sleeve includes a thin walled cylinder of sacrificial material.

[00027] Fig. 27 is a fragmentary cross-sectional illustration of the radial expansion and plastic deformation of a portion of a first tubular member having an internally threaded connection at an end portion, a second tubular member having an externally threaded portion coupled to the internally threaded portion of the first tubular member, and an embodiment of a tubular sleeve supported by the end portion of both tubular members. The sleeve includes a variable thickness along the length thereof.

[00028] Fig. 28 is a fragmentary cross-sectional illustration of the radial expansion and plastic deformation of a portion of a first tubular member having an internally threaded connection at an end portion, a second tubular member having an externally threaded portion coupled to the internally threaded portion of the first tubular member, and an embodiment of a tubular sleeve supported by the end portion of both tubular members. The sleeve includes a member coiled onto grooves formed in the sleeve for varying the sleeve thickness.

[00029] Fig. 29 is a fragmentary cross-sectional illustration of an exemplary embodiment of an expandable connection.

[00030] Figs. 30a-30c are fragmentary cross-sectional illustrations of exemplary embodiments of expandable connections.

[00031] Fig. 31 is a fragmentary cross-sectional illustration of an exemplary embodiment of an expandable connection.

[00032] Figs. 32a and 32b are fragmentary cross-sectional illustrations of the formation of an exemplary embodiment of an expandable connection.

[00033] Fig. 33 is a fragmentary cross-sectional illustration of an exemplary embodiment of an expandable connection.

[00034] Figs. 34a, 34b and 34c are fragmentary cross-sectional illustrations of an exemplary

embodiment of an expandable connection.

[00035] Fig. 35a is a fragmentary cross-sectional illustration of an exemplary embodiment of an expandable tubular member.

[00036] Fig. 35b is a graphical illustration of an exemplary embodiment of the variation in the yield point for the expandable tubular member of Fig. 35a.

[00037] Fig. 36a is a flow chart illustration of an exemplary embodiment of a method for processing a tubular member.

[00038] Fig. 36b is an illustration of the microstructure of an exemplary embodiment of a tubular member prior to thermal processing.

[00039] Fig. 36c is an illustration of the microstructure of an exemplary embodiment of a tubular member after thermal processing.

[00040] Fig. 37a is a flow chart illustration of an exemplary embodiment of a method for processing a tubular member.

[00041] Fig. 37b is an illustration of the microstructure of an exemplary embodiment of a tubular member prior to thermal processing.

[00042] Fig. 37c is an illustration of the microstructure of an exemplary embodiment of a tubular member after thermal processing.

[00043] Fig. 38a is a flow chart illustration of an exemplary embodiment of a method for processing a tubular member.

[00044] Fig. 38b is an illustration of the microstructure of an exemplary embodiment of a tubular member prior to thermal processing.

[00045] Fig. 38c is an illustration of the microstructure of an exemplary embodiment of a tubular member after thermal processing.

[00046] Fig. 39a is a fragmentary cross sectional illustration of an exemplary embodiment of expandable tubular members positioned within a preexisting structure.

[00047] Fig. 39b is a fragmentary cross sectional illustration of the expandable tubular members of Fig. 39a after placing an adjustable expansion device and a hydroforming expansion device within the expandable tubular members.

[00048] Fig. 39c is a fragmentary cross sectional illustration of the expandable tubular members of Fig. 39b after operating the hydroforming expansion device to radially expand and plastically deform at least a portion of the expandable tubular members.

[00049] Fig. 39d is a fragmentary cross sectional illustration of the expandable tubular members of Fig. 39c after operating the hydroforming expansion device to disengage from the expandable tubular members.

[00050] Fig. 39e is a fragmentary cross sectional illustration of the expandable tubular members of Fig. 39d after positioning the adjustable expansion device within the radially expanded portion of the expandable tubular members and then adjusting the size of the adjustable expansion device.

[00051] Fig. 39f is a fragmentary cross sectional illustration of the expandable tubular members of Fig. 39e after operating the adjustable expansion device to radially expand another portion of the expandable tubular members.

[00052] Fig. 40a is a fragmentary cross sectional illustration of an exemplary embodiment of expandable tubular members positioned within a preexisting structure.

[00053] Fig. 40b is a fragmentary cross sectional illustration of the expandable tubular members of Fig. 40a after placing a hydroforming expansion device within a portion of the expandable tubular members.

[00054] Fig. 40c is a fragmentary cross sectional illustration of the expandable tubular members of Fig. 40b after operating the hydroforming expansion device to radially expand and plastically deform at least a portion of the expandable tubular members.

[00055] Fig. 40d is a fragmentary cross sectional illustration of the expandable tubular members of Fig. 40c after placing the hydroforming expansion device within another portion of the expandable tubular members.

[00056] Fig. 40e is a fragmentary cross sectional illustration of the expandable tubular members of Fig. 40d after operating the hydroforming expansion device to radially expand and plastically deform at least another portion of the expandable tubular members.

[00057] Fig. 40f is a fragmentary cross sectional illustration of the expandable tubular members of Fig. 40e after placing the hydroforming expansion device within another portion of the expandable tubular members.

[00058] Fig. 40g is a fragmentary cross sectional illustration of the expandable tubular members of Fig. 40f after operating the hydroforming expansion device to radially expand and plastically deform at least another portion of the expandable tubular members.

[00059] Fig. 41a is a fragmentary cross sectional illustration of an exemplary embodiment of expandable tubular members positioned within a preexisting structure, wherein the bottom most tubular member includes a valveable passageway.

[00060] Fig. 41b is a fragmentary cross sectional illustration of the expandable tubular members of Fig. 41a after placing a hydroforming expansion device within the lower most expandable tubular member.

[00061] Fig. 41c is a fragmentary cross sectional illustration of the expandable tubular members of Fig. 41b after operating the hydroforming expansion device to radially expand and plastically deform at least a portion of the lower most expandable tubular member.

[00062] Fig. 41d is a fragmentary cross sectional illustration of the expandable tubular members of Fig. 41c after disengaging hydroforming expansion device from the lower most expandable tubular member.

[00063] Fig. 41e is a fragmentary cross sectional illustration of the expandable tubular members of Fig. 41d after positioning the adjustable expansion device within the radially expanded and plastically

deformed portion of the lower most expandable tubular member.

[00064] Fig. 41f is a fragmentary cross sectional illustration of the expandable tubular members of Fig. 41e after operating the adjustable expansion device to engage the radially expanded and plastically deformed portion of the lower most expandable tubular member.

[00065] Fig. 41g is a fragmentary cross sectional illustration of the expandable tubular members of Fig. 41f after operating the adjustable expansion device to radially expand and plastically deform at least another portion of the expandable tubular members.

[00066] Fig. 41h is a fragmentary cross sectional illustration of the expandable tubular members of Fig. 41g after machining away the lower most portion of the lower most expandable tubular member.

[00067] Fig. 42a is a fragmentary cross sectional illustration of an exemplary embodiment of tubular members positioned within a preexisting structure, wherein one of the tubular members includes one or more radial passages.

[00068] Fig. 42b is a fragmentary cross sectional illustration of the tubular members of Fig. 42a after placing a hydroforming casing patch device within the tubular member having the radial passages.

[00069] Fig. 42c is a fragmentary cross sectional illustration of the tubular members of Fig. 42b after operating the hydroforming expansion device to radially expand and plastically deform a tubular casing patch into engagement with the tubular member having the radial passages.

[00070] Fig. 42d is a fragmentary cross sectional illustration of the expandable tubular members of Fig. 42c after disengaging the hydroforming expansion device from the tubular member having the radial passages.

[00071] Fig. 42e is a fragmentary cross sectional illustration of the expandable tubular members of Fig. 42d after removing the hydroforming expansion device from the tubular member having the radial passages.

[00072] Fig. 43 is a schematic illustration of an exemplary embodiment of a hydroforming expansion device.

[00073] Figs. 44a-44b are flow chart illustrations of an exemplary method of operating the hydroforming expansion device of Fig. 43.

[00074] Fig. 45a is a fragmentary cross sectional illustration of an exemplary embodiment of a radial expansion system positioned within a cased section of a wellbore.

[00075] Fig. 45b is a fragmentary cross sectional illustration of the system of Fig. 45a following the placement of a ball within the throat passage of the system.

[00076] Fig. 45c is a fragmentary cross sectional illustration of the system of Fig. 45b during the injection of fluidic materials to burst the burst disc of the system.

[00077] Fig. 45d is a fragmentary cross sectional illustration of the system of Fig. 45c during the continued injection of fluidic materials to radially expand and plastically deform at least a portion of the tubular liner hanger.

[00078] Fig. 45e is a fragmentary cross sectional illustration of the system of Fig. 45d during the

continued injection of fluidic materials to adjust the size of the adjustable expansion device assembly.

[00079] Fig. 45f is a fragmentary cross sectional illustration of the system of Fig. 45e during the displacement of the adjustable expansion device assembly to radially expand another portion of the tubular liner hanger.

[00080] Fig. 45g is a fragmentary cross sectional illustration of the system of Fig. 45f following the removal of the system from the wellbore.

[00081] Fig. 46a is a fragmentary cross sectional illustration of an exemplary embodiment of a radial expansion system positioned within a cased section of a wellbore.

[00082] Fig. 46b is a fragmentary cross sectional illustration of the system of Fig. 46a following the placement of a plug within the throat passage of the system.

[00083] Fig. 46c is a fragmentary cross sectional illustration of the system of Fig. 46b during the injection of fluidic materials to burst the burst disc of the system.

[00084] Fig. 46d is a fragmentary cross sectional illustration of the system of Fig. 46c during the continued injection of fluidic materials to radially expand and plastically deform at least a portion of the tubular liner hanger.

[00085] Fig. 46e is a fragmentary cross sectional illustration of the system of Fig. 46d during the continued injection of fluidic materials to adjust the size of the adjustable expansion device assembly.

[00086] Fig. 46f is a fragmentary cross sectional illustration of the system of Fig. 46e during the displacement of the adjustable expansion device assembly to radially expand another portion of the tubular liner hanger.

[00087] Fig. 46g is a top view of a portion of an exemplary embodiment of an expansion limiter sleeve prior to the radial expansion and plastic deformation of the expansion limiter sleeve.

[00088] Fig. 46h is a top view of a portion of the expansion limiter sleeve of Fig. 46g after the radial expansion and plastic deformation of the expansion limiter sleeve.

[00089] Fig. 46i is a top view of a portion of an exemplary embodiment of an expansion limiter sleeve prior to the radial expansion and plastic deformation of the expansion limiter sleeve.

[00090] Fig. 46ia is a fragmentary cross sectional view of the expansion limiter sleeve of Fig. 46i.

[00091] Fig. 46j is a top view of a portion of the expansion limiter sleeve of Fig. 46i after the radial expansion and plastic deformation of the expansion limiter sleeve.

[00092] Fig. 47a is a fragmentary cross sectional illustration of an exemplary embodiment of a system for radially expanding and plastically deforming a tubular member during the injection of a hardenable fluidic sealing material into the system.

[00093] Fig. 47b is a fragmentary cross sectional illustration of the system of Fig. 47a during the subsequent placement of a plug within the flow passages of the system to permit the passages of the system to be pressurized.

[00094] Fig. 47c is a fragmentary cross sectional illustration of the system of Fig. 47b during the subsequent pressurization of the flow passages of the system to operate and displace the expansion cone

of the system to radially expand and plastically deform a portion of the expandable tubular casing.

[00095] Fig. 47d is a fragmentary cross sectional illustration of the system of Fig. 47c during the subsequent continued pressurization of the flow passages of the system to operate and displace the expansion cones of the system to radially expand and plastically deform further portions of the expandable tubular casing and a portion of the expandable tubular sleeve.

[00096] Fig. 47e is a fragmentary cross sectional illustration of the system of Fig. 47d during the subsequent pressurization of the flow passages of the system to operate and displace the expansion cone of the system to radially expand and plastically deform further portions of the expandable tubular casing.

[00097] Fig. 48a is a fragmentary cross sectional illustration of an exemplary embodiment of a system for radially expanding and plastically deforming a tubular member during the injection of a hardenable fluidic sealing material into the system.

[00098] Fig. 48b is a fragmentary cross sectional illustration of the system of Fig. 48a during the subsequent placement of a plug within the flow passages of the system to permit the passages of the system to be pressurized.

[00099] Fig. 48c is a fragmentary cross sectional illustration of the system of Fig. 48b during the subsequent pressurization of the flow passages of the system to operate and adjust the size of the adjustable expansion device of the system.

[000100] Fig. 48d is a fragmentary cross sectional illustration of the system of Fig. 48c during the subsequent pressurization of the flow passages of the system to operate and displace the expansion device of the system to radially expand and plastically deform a portion of the expandable tubular casing.

[000101] Fig. 48e is a fragmentary cross sectional illustration of the system of Fig. 48d during the subsequent continued pressurization of the flow passages of the system to operate and displace the expansion device of the system to radially expand and plastically deform further portions of the expandable tubular casing and a portion of the expandable tubular sleeve.

[000102] Fig. 48f is a fragmentary cross sectional illustration of the system of Fig. 48e during the subsequent pressurization of the flow passages of the system to operate and displace the expansion cone of the system to radially expand and plastically deform further portions of the expandable tubular casing.

[000103] Fig. 49a is a fragmentary cross sectional illustration of an exemplary embodiment of a system for radially expanding and plastically deforming a tubular member during the injection of a hardenable fluidic sealing material into the system.

[000104] Fig. 49b is a fragmentary cross sectional illustration of the system of Fig. 49a during the subsequent placement of a plug within the flow passages of the system to permit the passages of the system to be pressurized.

[000105] Fig. 49c is a fragmentary cross sectional illustration of the system of Fig. 49b during the subsequent pressurization of the flow passages of the system to operate and adjust the size of the adjustable expansion device of the system.

[000106] Fig. 49d is a fragmentary cross sectional illustration of the system of Fig. 49c during the

subsequent pressurization of the flow passages of the system to operate and displace the expansion device of the system to radially expand and plastically deform a portion of the expandable tubular casing.

[000107] Fig. 49e is a fragmentary cross sectional illustration of the system of Fig. 49d during the subsequent continued pressurization of the flow passages of the system to operate and displace the expansion device of the system to radially expand and plastically deform further portions of the expandable tubular casing and a portion of the expandable tubular sleeve.

[000108] Fig. 49f is a fragmentary cross sectional illustration of the system of Fig. 49e during the subsequent pressurization of the flow passages of the system to operate and displace the expansion cone of the system to radially expand and plastically deform further portions of the expandable tubular casing.

[000109] Fig. 50a is a fragmentary cross sectional illustration of an exemplary embodiment of a system for radially expanding and plastically deforming a tubular member during the injection of a hardenable fluidic sealing material into the system.

[000110] Fig. 50aa is an enlarged illustration of a portion of the system of Fig. 50a.

[000111] Fig. 50ab is a cross sectional illustration of the portion of Fig. 50aa taken along the line 50ab-50ab of Fig. 50aa.

[000112] Fig. 50b is a fragmentary cross sectional illustration of the system of Fig. 50a during the subsequent placement of a plug within the flow passages of the system to permit the passages of the system to be pressurized.

[000113] Fig. 50c is a fragmentary cross sectional illustration of the system of Fig. 50b during the subsequent pressurization of the flow passages of the system to operate and adjust the size of the adjustable expansion device of the system to radially expand and plastically deform a portion of the expandable sleeve.

[000114] Fig. 50ca is an enlarged illustration of a portion of the system of Fig. 50c.

[000115] Fig. 50cb is a cross sectional illustration of the portion of Fig. 50ca taken along the line 50cb-50cb of Fig. 50ca.

[000116] Fig. 50d is a fragmentary cross sectional illustration of the system of Fig. 50c during the subsequent pressurization of the flow passages of the system to operate and displace the expansion device of the system to radially expand and plastically deform a portion of the expandable tubular casing and release the expandable tubular casing from engagement with the casing lock assembly.

[000117] Fig. 50e is a fragmentary cross sectional illustration of the system of Fig. 50d during the subsequent continued pressurization of the flow passages of the system to operate and displace the expansion device of the system to radially expand and plastically deform further portions of the expandable tubular casing.

[000118] Fig. 50f is a fragmentary cross sectional illustration of the system of Fig. 50b during an emergency release of the expandable tubular casing from engagement with the locking dogs of the casing lock assembly.

[000119] Fig. 51 is a graphical illustration of an exemplary experimental embodiment.

[000120] Fig. 52 is a graphical illustration of an exemplary experimental embodiment.

[000121] Fig. 53 is a flow chart illustration of an exemplary embodiment of a method of processing tubular members.

[000122] Fig. 54 is a graphical illustration of an exemplary embodiment of a method of processing tubular members.

[000123] Fig. 55 is a graphical illustration of an exemplary embodiment of a method of processing tubular members.

[000124] Fig. 56 is a graphical illustration of an exemplary embodiment of a method of processing tubular members.

[000125] Detailed Description of the Illustrative Embodiments

[000126] Referring initially to Fig. 1, an exemplary embodiment of an expandable tubular assembly 10 includes a first expandable tubular member 12 coupled to a second expandable tubular member 14. In several exemplary embodiments, the ends of the first and second expandable tubular members, 12 and 14, are coupled using, for example, a conventional mechanical coupling, a welded connection, a brazed connection, a threaded connection, and/or an interference fit connection. In an exemplary embodiment, the first expandable tubular member 12 has a plastic yield point YP1, and the second expandable tubular member 14 has a plastic yield point YP2. In an exemplary embodiment, the expandable tubular assembly 10 is positioned within a preexisting structure such as, for example, a wellbore 16 that traverses a subterranean formation 18.

[000127] As illustrated in Fig. 2, an expansion device 20 may then be positioned within the second expandable tubular member 14. In several exemplary embodiments, the expansion device 20 may include, for example, one or more of the following conventional expansion devices: a) an expansion cone; b) a rotary expansion device; c) a hydroforming expansion device; d) an impulsive force expansion device; d) any one of the expansion devices commercially available from, or disclosed in any of the published patent applications or issued patents, of Weatherford International, Baker Hughes, Halliburton Energy Services, Shell Oil Co., Schlumberger, and/or Enventure Global Technology L.L.C. In several exemplary embodiments, the expansion device 20 is positioned within the second expandable tubular member 14 before, during, or after the placement of the expandable tubular assembly 10 within the preexisting structure 16.

[000128] As illustrated in Fig. 3, the expansion device 20 may then be operated to radially expand and plastically deform at least a portion of the second expandable tubular member 14 to form a bell-shaped section.

[000129] As illustrated in Fig. 4, the expansion device 20 may then be operated to radially expand and plastically deform the remaining portion of the second expandable tubular member 14 and at least a portion of the first expandable tubular member 12.

[000130] In an exemplary embodiment, at least a portion of at least a portion of at least one of the first and second expandable tubular members, 12 and 14, are radially expanded into intimate contact with the

interior surface of the preexisting structure 16.

[000131] In an exemplary embodiment, as illustrated in Fig. 5, the plastic yield point YP1 is greater than the plastic yield point YP2. In this manner, in an exemplary embodiment, the amount of power and/or energy required to radially expand the second expandable tubular member 14 is less than the amount of power and/or energy required to radially expand the first expandable tubular member 12.

[000132] In an exemplary embodiment, as illustrated in Fig. 6, the first expandable tubular member 12 and/or the second expandable tubular member 14 have a ductility DPE and a yield strength YSPE prior to radial expansion and plastic deformation, and a ductility DAE and a yield strength YSAE after radial expansion and plastic deformation. In an exemplary embodiment, DPE is greater than DAE, and YSAE is greater than YSPE. In this manner, the first expandable tubular member 12 and/or the second expandable tubular member 14 are transformed during the radial expansion and plastic deformation process. Furthermore, in this manner, in an exemplary embodiment, the amount of power and/or energy required to radially expand each unit length of the first and/or second expandable tubular members, 12 and 14, is reduced. Furthermore, because the YSAE is greater than YSPE, the collapse strength of the first expandable tubular member 12 and/or the second expandable tubular member 14 is increased after the radial expansion and plastic deformation process.

[000133] In an exemplary embodiment, as illustrated in Fig. 7, following the completion of the radial expansion and plastic deformation of the expandable tubular assembly 10 described above with reference to Figs. 1-4, at least a portion of the second expandable tubular member 14 has an inside diameter that is greater than at least the inside diameter of the first expandable tubular member 12. In this manner a bell-shaped section is formed using at least a portion of the second expandable tubular member 14. Another expandable tubular assembly 22 that includes a first expandable tubular member 24 and a second expandable tubular member 26 may then be positioned in overlapping relation to the first expandable tubular assembly 10 and radially expanded and plastically deformed using the methods described above with reference to Figs. 1-4. Furthermore, following the completion of the radial expansion and plastic deformation of the expandable tubular assembly 20, in an exemplary embodiment, at least a portion of the second expandable tubular member 26 has an inside diameter that is greater than at least the inside diameter of the first expandable tubular member 24. In this manner a bell-shaped section is formed using at least a portion of the second expandable tubular member 26. Furthermore, in this manner, a mono-diameter tubular assembly is formed that defines an internal passage 28 having a substantially constant cross-sectional area and/or inside diameter.

[000134] Referring to Fig. 8, an exemplary embodiment of an expandable tubular assembly 100 includes a first expandable tubular member 102 coupled to a tubular coupling 104. The tubular coupling 104 is coupled to a tubular coupling 106. The tubular coupling 106 is coupled to a second expandable tubular member 108. In several exemplary embodiments, the tubular couplings, 104 and 106, provide a tubular coupling assembly for coupling the first and second expandable tubular members, 102 and 108, together that may include, for example, a conventional mechanical coupling, a welded connection, a

brazed connection, a threaded connection, and/or an interference fit connection. In an exemplary embodiment, the first and second expandable tubular members 12 have a plastic yield point YP1, and the tubular couplings, 104 and 106, have a plastic yield point YP2. In an exemplary embodiment, the expandable tubular assembly 100 is positioned within a preexisting structure such as, for example, a wellbore 110 that traverses a subterranean formation 112.

[000135] As illustrated in Fig. 9, an expansion device 114 may then be positioned within the second expandable tubular member 108. In several exemplary embodiments, the expansion device 114 may include, for example, one or more of the following conventional expansion devices: a) an expansion cone; b) a rotary expansion device; c) a hydroforming expansion device; d) an impulsive force expansion device; d) any one of the expansion devices commercially available from, or disclosed in any of the published patent applications or issued patents, of Weatherford International, Baker Hughes, Halliburton Energy Services, Shell Oil Co., Schlumberger, and/or Enventure Global Technology L.L.C. In several exemplary embodiments, the expansion device 114 is positioned within the second expandable tubular member 108 before, during, or after the placement of the expandable tubular assembly 100 within the preexisting structure 110.

[000136] As illustrated in Fig. 10, the expansion device 114 may then be operated to radially expand and plastically deform at least a portion of the second expandable tubular member 108 to form a bell-shaped section.

[000137] As illustrated in Fig. 11, the expansion device 114 may then be operated to radially expand and plastically deform the remaining portion of the second expandable tubular member 108, the tubular couplings, 104 and 106, and at least a portion of the first expandable tubular member 102.

[000138] In an exemplary embodiment, at least a portion of at least a portion of at least one of the first and second expandable tubular members, 102 and 108, are radially expanded into intimate contact with the interior surface of the preexisting structure 110.

[000139] In an exemplary embodiment, as illustrated in Fig. 12, the plastic yield point YP1 is less than the plastic yield point YP2. In this manner, in an exemplary embodiment, the amount of power and/or energy required to radially expand each unit length of the first and second expandable tubular members, 102 and 108, is less than the amount of power and/or energy required to radially expand each unit length of the tubular couplings, 104 and 106.

[000140] In an exemplary embodiment, as illustrated in Fig. 13, the first expandable tubular member 12 and/or the second expandable tubular member 14 have a ductility DPE and a yield strength YSPE prior to radial expansion and plastic deformation, and a ductility DAE and a yield strength YSAE after radial expansion and plastic deformation. In an exemplary embodiment, DPE is greater than DAE, and YSAE is greater than YSPE. In this manner, the first expandable tubular member 12 and/or the second expandable tubular member 14 are transformed during the radial expansion and plastic deformation process. Furthermore, in this manner, in an exemplary embodiment, the amount of power and/or energy required to radially expand each unit length of the first and/or second expandable tubular members, 12

and 14, is reduced. Furthermore, because the YSAE is greater than YSPE, the collapse strength of the first expandable tubular member 12 and/or the second expandable tubular member 14 is increased after the radial expansion and plastic deformation process.

[000141] Referring to Fig. 14, an exemplary embodiment of an expandable tubular assembly 200 includes a first expandable tubular member 202 coupled to a second expandable tubular member 204 that defines radial openings 204a, 204b, 204c, and 204d. In several exemplary embodiments, the ends of the first and second expandable tubular members, 202 and 204, are coupled using, for example, a conventional mechanical coupling, a welded connection, a brazed connection, a threaded connection, and/or an interference fit connection. In an exemplary embodiment, one or more of the radial openings, 204a, 204b, 204c, and 204d, have circular, oval, square, and/or irregular cross sections and/or include portions that extend to and interrupt either end of the second expandable tubular member 204. In an exemplary embodiment, the expandable tubular assembly 200 is positioned within a preexisting structure such as, for example, a wellbore 206 that traverses a subterranean formation 208.

[000142] As illustrated in Fig. 15, an expansion device 210 may then be positioned within the second expandable tubular member 204. In several exemplary embodiments, the expansion device 210 may include, for example, one or more of the following conventional expansion devices: a) an expansion cone; b) a rotary expansion device; c) a hydroforming expansion device; d) an impulsive force expansion device; d) any one of the expansion devices commercially available from, or disclosed in any of the published patent applications or issued patents, of Weatherford International, Baker Hughes, Halliburton Energy Services, Shell Oil Co., Schlumberger, and/or Enventure Global Technology L.L.C. In several exemplary embodiments, the expansion device 210 is positioned within the second expandable tubular member 204 before, during, or after the placement of the expandable tubular assembly 200 within the preexisting structure 206.

[000143] As illustrated in Fig. 16, the expansion device 210 may then be operated to radially expand and plastically deform at least a portion of the second expandable tubular member 204 to form a bell-shaped section.

[000144] As illustrated in Fig. 16, the expansion device 20 may then be operated to radially expand and plastically deform the remaining portion of the second expandable tubular member 204 and at least a portion of the first expandable tubular member 202.

[000145] In an exemplary embodiment, the anisotropy ratio AR for the first and second expandable tubular members is defined by the following equation:

[000146] AR = ln (WTf/WTo)/ln (Df/Do);

[000147] where AR = anisotropy ratio;

[000148] where WTf = final wall thickness of the expandable tubular member following the radial expansion and plastic deformation of the expandable tubular member;

[000149] where WTi = initial wall thickness of the expandable tubular member prior to the radial expansion and plastic deformation of the expandable tubular member;

[000150] where Df = final inside diameter of the expandable tubular member following the radial expansion and plastic deformation of the expandable tubular member; and

[000151] where Di = initial inside diameter of the expandable tubular member prior to the radial expansion and plastic deformation of the expandable tubular member.

[000152] In an exemplary embodiment, the anisotropy ratio AR for the first and/or second expandable tubular members, 202 and 204, is greater than 1.

[000153] In an exemplary experimental embodiment, the second expandable tubular member 204 had an anisotropy ratio AR greater than 1, and the radial expansion and plastic deformation of the second expandable tubular member did not result in any of the openings, 204a, 204b, 204c, and 204d, splitting or otherwise fracturing the remaining portions of the second expandable tubular member. This was an unexpected result.

[000154] Referring to Fig. 18, in an exemplary embodiment, one or more of the expandable tubular members, 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204 are processed using a method 300 in which a tubular member in an initial state is thermo-mechanically processed in step 302. In an exemplary embodiment, the thermo-mechanical processing 302 includes one or more heat treating and/or mechanical forming processes. As a result, of the thermo-mechanical processing 302, the tubular member is transformed to an intermediate state. The tubular member is then further thermo-mechanically processed in step 304. In an exemplary embodiment, the thermo-mechanical processing 304 includes one or more heat treating and/or mechanical forming processes. As a result, of the thermo-mechanical processing 304, the tubular member is transformed to a final state.

[000155] In an exemplary embodiment, as illustrated in Fig. 19, during the operation of the method 300, the tubular member has a ductility $D_{PE}$ and a yield strength $YS_{PE}$ prior to the final thermo-mechanical processing in step 304, and a ductility $D_{AE}$ and a yield strength $YS_{AE}$ after final thermo-mechanical processing. In an exemplary embodiment, $D_{PE}$ is greater than $D_{AE}$, and $YS_{AE}$ is greater than $YS_{PE}$. In this manner, the amount of energy and/or power required to transform the tubular member, using mechanical forming processes, during the final thermo-mechanical processing in step 304 is reduced. Furthermore, in this manner, because the $YS_{AE}$ is greater than $YS_{PE}$, the collapse strength of the tubular member is increased after the final thermo-mechanical processing in step 304.

[000156] In an exemplary embodiment, one or more of the expandable tubular members, 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204, have the following characteristics:

| Characteristic | Value |
|---|---|
| Tensile Strength | 60 to 120 ksi |
| Yield Strength | 50 to 100 ksi |
| Y/T Ratio | Maximum of 50/85 % |
| Elongation During Radial Expansion and Plastic Deformation | Minimum of 35 % |
| Width Reduction During Radial Expansion and Plastic Deformation | Minimum of 40 % |
| Wall Thickness Reduction During Radial | Minimum of 30 % |

| Characteristic | Value |
|---|---|
| Expansion and Plastic Deformation | |
| Anisotropy | Minimum of 1.5 |
| Minimum Absorbed Energy at -4 F (-20 C) in the Longitudinal Direction | 80 ft-lb |
| Minimum Absorbed Energy at -4 F (-20 C) in the Transverse Direction | 60 ft-lb |
| Minimum Absorbed Energy at -4 F (-20 C) Transverse To A Weld Area | 60 ft-lb |
| Flare Expansion Testing | Minimum of 75% Without A Failure |
| Increase in Yield Strength Due To Radial Expansion and Plastic Deformation | Greater than 5.4 % |

[000157] In an exemplary embodiment, one or more of the expandable tubular members, 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204, are characterized by an expandability coefficient f:

i. f = r X n

ii. where f = expandability coefficient;

1. r = anisotropy coefficient; and
2. n = strain hardening exponent.

[000158] In an exemplary embodiment, the anisotropy coefficient for one or more of the expandable tubular members, 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204 is greater than 1. In an exemplary embodiment, the strain hardening exponent for one or more of the expandable tubular members, 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204 is greater than 0.12. In an exemplary embodiment, the expandability coefficient for one or more of the expandable tubular members, 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204 is greater than 0.12.

[000159] In an exemplary embodiment, a tubular member having a higher expandability coefficient requires less power and/or energy to radially expand and plastically deform each unit length than a tubular member having a lower expandability coefficient. In an exemplary embodiment, a tubular member having a higher expandability coefficient requires less power and/or energy per unit length to radially expand and plastically deform than a tubular member having a lower expandability coefficient.

[000160] In several exemplary experimental embodiments, one or more of the expandable tubular members, 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204, are steel alloys having one of the following compositions:

| | **Element and Percentage By Weight** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Steel Alloy** | **C** | **Mn** | **P** | **S** | **Si** | **Cu** | **Ni** | **Cr** |
| **A** | 0.065 | 1.44 | 0.01 | 0.002 | 0.24 | 0.01 | 0.01 | 0.02 |
| **B** | 0.18 | 1.28 | 0.017 | 0.004 | 0.29 | 0.01 | 0.01 | 0.03 |
| **C** | 0.08 | 0.82 | 0.006 | 0.003 | 0.30 | 0.16 | 0.05 | 0.05 |
| **D** | 0.02 | 1.31 | 0.02 | 0.001 | 0.45 | - | 9.1 | 18.7 |

[000161] In exemplary experimental embodiment, as illustrated in Fig. 20, a sample of an expandable

tubular member composed of Alloy A exhibited a yield point before radial expansion and plastic deformation YPBE, a yield point after radial expansion and plastic deformation of about 16 % YPAE16%, and a yield point after radial expansion and plastic deformation of about 24 % YPAE24%. In an exemplary experimental embodiment, YPAE24% > YPAE16% > YPBE. Furthermore, in an exemplary experimental embodiment, the ductility of the sample of the expandable tubular member composed of Alloy A also exhibited a higher ductility prior to radial expansion and plastic deformation than after radial expansion and plastic deformation. These were unexpected results.

[000162] In an exemplary experimental embodiment, a sample of an expandable tubular member composed of Alloy A exhibited the following tensile characteristics before and after radial expansion and plastic deformation:

| | **Yield Point ksi** | **Yield Ratio** | **Elongation %** | **Width Reduction %** | **Wall Thickness Reduction %** | **Anisotropy** |
|---|---|---|---|---|---|---|
| **Before Radial Expansion and Plastic Deformation** | 46.9 | 0.69 | 53 | -52 | 55 | 0.93 |
| **After 16% Radial Expansion** | 65.9 | 0.83 | 17 | 42 | 51 | 0.78 |
| **After 24% Radial Expansion** | 68.5 | 0.83 | 5 | 44 | 54 | 0.76 |
| **% Increase** | 40% for 16% radial expansion 46% for 24% radial expansion | | | | | |

[000163] In exemplary experimental embodiment, as illustrated in Fig. 21, a sample of an expandable tubular member composed of Alloy B exhibited a yield point before radial expansion and plastic deformation $YP_{BE}$, a yield point after radial expansion and plastic deformation of about 16 % $YP_{AE16\%}$, and a yield point after radial expansion and plastic deformation of about 24 % $YP_{AE24\%}$. In an exemplary embodiment, $YP_{AE24\%} > YP_{AE16\%} > YP_{BE}$. Furthermore, in an exemplary experimental embodiment, the ductility of the sample of the expandable tubular member composed of Alloy B also exhibited a higher ductility prior to radial expansion and plastic deformation than after radial expansion and plastic deformation. These were unexpected results.

[000164] In an exemplary experimental embodiment, a sample of an expandable tubular member composed of Alloy B exhibited the following tensile characteristics before and after radial expansion and plastic deformation:

| | Yield Point ksi | Yield Ratio | Elongation % | Width Reduction % | Wall Thickness Reduction % | Anisotropy |
|---|---|---|---|---|---|---|
| **Before Radial Expansion and Plastic Deformation** | 57.8 | 0.71 | 44 | 43 | 46 | 0.93 |
| **After 16% Radial Expansion** | 74.4 | 0.84 | 16 | 38 | 42 | 0.87 |
| **After 24% Radial Expansion** | 79.8 | 0.86 | 20 | 36 | 42 | 0.81 |
| **% Increase** | 28.7% increase for 16% radial expansion 38% increase for 24% radial expansion | | | | | |

[000165] In an exemplary experimental embodiment, samples of expandable tubulars composed of Alloys A, B, C, and D exhibited the following tensile characteristics prior to radial expansion and plastic deformation:

| Steel Alloy | Yield ksi | Yield Ratio | Elongation % | Anisotropy | Absorbed Energy ft-lb | Expandability Coefficient |
|---|---|---|---|---|---|---|
| A | 47.6 | 0.71 | 44 | 1.48 | 145 | |
| B | 57.8 | 0.71 | 44 | 1.04 | 62.2 | |
| C | 61.7 | 0.80 | 39 | 1.92 | 268 | |
| D | 48 | 0.55 | 56 | 1.34 | - | |

[000166] In an exemplary embodiment, one or more of the expandable tubular members, 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204 have a strain hardening exponent greater than 0.12, and a yield ratio is less than 0.85.

[000167] In an exemplary embodiment, the carbon equivalent $C_e$, for tubular members having a carbon content (by weight percentage) less than or equal to 0.12%, is given by the following expression:

$$C_e = C + Mn/6 + (Cr + Mo + V + Ti + Nb)/5 + (Ni + Cu)/15$$

where $C_e$ = carbon equivalent value;

a. C = carbon percentage by weight;

b. Mn = manganese percentage by weight;

c. Cr = chromium percentage by weight;

d. Mo = molybdenum percentage by weight;

e. V = vanadium percentage by weight;

f. Ti = titanium percentage by weight;

g. Nb = niobium percentage by weight;

h. Ni = nickel percentage by weight; and

i. Cu = copper percentage by weight.

[000168] In an exemplary embodiment, the carbon equivalent value Ce, for tubular members having a carbon content less than or equal to 0.12% (by weight), for one or more of the expandable tubular members, 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204 is less than 0.21.

[000169] In an exemplary embodiment, the carbon equivalent Ce, for tubular members having more than 0.12% carbon content (by weight), is given by the following expression:

[000170] $$C_e = C + Si/30 + (Mn + Cu + Cr)/20 + Ni/60 + Mo/15 + V/10 + 5*B$$

[000171] where Ce = carbon equivalent value;

[000172] C = carbon percentage by weight;

[000173] Si = silicon percentage by weight;

[000174] Mn = manganese percentage by weight;

[000175] Cu = copper percentage by weight;

[000176] Cr = chromium percentage by weight;

[000177] Ni = nickel percentage by weight;

[000178] Mo = molybdenum percentage by weight;

[000179] V = vanadium percentage by weight; and

[000180] B = boron percentage by weight.

[000181] In an exemplary embodiment, the carbon equivalent value Ce, for tubular members having greater than 0.12% carbon content (by weight), for one or more of the expandable tubular members, 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204 is less than 0.36.

[000182] Referring to Fig. 22 in an exemplary embodiment, a first tubular member 2210 includes an internally threaded connection 2212 at an end portion 2214. A first end of a tubular sleeve 2216 that includes an internal flange 2218 having a tapered portion 2220, and a second end that includes a tapered portion 2222, is then mounted upon and receives the end portion 2214 of the first tubular member 2210. In an exemplary embodiment, the end portion 2214 of the first tubular member 2210 abuts one side of the internal flange 2218 of the tubular sleeve 2216, and the internal diameter of the internal flange 2218 of the tubular sleeve 2216 is substantially equal to or greater than the maximum internal diameter of the internally threaded connection 2212 of the end portion 2214 of the first tubular member 2210. An externally threaded connection 2224 of an end portion 2226 of a second tubular member 2228 having an annular recess 2230 is then positioned within the tubular sleeve 2216 and threadably coupled to the internally threaded connection 2212 of the end portion 2214 of the first tubular member 2210. In an exemplary embodiment, the internal flange 2218 of the tubular sleeve 2216 mates with and is received

within the annular recess 2230 of the end portion 2226 of the second tubular member 2228. Thus, the tubular sleeve 2216 is coupled to and surrounds the external surfaces of the first and second tubular members, 2210 and 2228.

[000183] The internally threaded connection 2212 of the end portion 2214 of the first tubular member 2210 is a box connection, and the externally threaded connection 2224 of the end portion 2226 of the second tubular member 2228 is a pin connection. In an exemplary embodiment, the internal diameter of the tubular sleeve 2216 is at least approximately .020" greater than the outside diameters of the first and second tubular members, 2210 and 2228. In this manner, during the threaded coupling of the first and second tubular members, 2210 and 2228, fluidic materials within the first and second tubular members may be vented from the tubular members.

[000184] As illustrated in Fig. 22, the first and second tubular members, 2210 and 2228, and the tubular sleeve 2216 may be positioned within another structure 2232 such as, for example, a cased or uncased wellbore, and radially expanded and plastically deformed, for example, by displacing and/or rotating a conventional expansion device 2234 within and/or through the interiors of the first and second tubular members. The tapered portions, 2220 and 2222, of the tubular sleeve 2216 facilitate the insertion and movement of the first and second tubular members within and through the structure 2232, and the movement of the expansion device 2234 through the interiors of the first and second tubular members, 2210 and 2228, may be, for example, from top to bottom or from bottom to top.

[000185] During the radial expansion and plastic deformation of the first and second tubular members, 2210 and 2228, the tubular sleeve 2216 is also radially expanded and plastically deformed. As a result, the tubular sleeve 2216 may be maintained in circumferential tension and the end portions, 2214 and 2226, of the first and second tubular members, 2210 and 2228, may be maintained in circumferential compression.

[000186] Sleeve 2216 increases the axial compression loading of the connection between tubular members 2210 and 2228 before and after expansion by the expansion device 2234. Sleeve 2216 may, for example, be secured to tubular members 2210 and 2228 by a heat shrink fit.

[000187] In several alternative embodiments, the first and second tubular members, 2210 and 2228, are radially expanded and plastically deformed using other conventional methods for radially expanding and plastically deforming tubular members such as, for example, internal pressurization, hydroforming, and/or roller expansion devices and/or any one or combination of the conventional commercially available expansion products and services available from Baker Hughes, Weatherford International, and/or Enventure Global Technology L.L.C.

[000188] The use of the tubular sleeve 2216 during (a) the coupling of the first tubular member 2210 to the second tubular member 2228, (b) the placement of the first and second tubular members in the structure 2232, and (c) the radial expansion and plastic deformation of the first and second tubular members provides a number of significant benefits. For example, the tubular sleeve 2216 protects the exterior surfaces of the end portions, 2214 and 2226, of the first and second tubular members, 2210 and

2228, during handling and insertion of the tubular members within the structure 2232. In this manner, damage to the exterior surfaces of the end portions, 2214 and 2226, of the first and second tubular members, 2210 and 2228, is avoided that could otherwise result in stress concentrations that could cause a catastrophic failure during subsequent radial expansion operations. Furthermore, the tubular sleeve 2216 provides an alignment guide that facilitates the insertion and threaded coupling of the second tubular member 2228 to the first tubular member 2210. In this manner, misalignment that could result in damage to the threaded connections, 2212 and 2224, of the first and second tubular members, 2210 and 2228, may be avoided. In addition, during the relative rotation of the second tubular member with respect to the first tubular member, required during the threaded coupling of the first and second tubular members, the tubular sleeve 2216 provides an indication of to what degree the first and second tubular members are threadably coupled. For example, if the tubular sleeve 2216 can be easily rotated, that would indicate that the first and second tubular members, 2210 and 2228, are not fully threadably coupled and in intimate contact with the internal flange 2218 of the tubular sleeve. Furthermore, the tubular sleeve 2216 may prevent crack propagation during the radial expansion and plastic deformation of the first and second tubular members, 2210 and 2228. In this manner, failure modes such as, for example, longitudinal cracks in the end portions, 2214 and 2226, of the first and second tubular members may be limited in severity or eliminated all together. In addition, after completing the radial expansion and plastic deformation of the first and second tubular members, 2210 and 2228, the tubular sleeve 2216 may provide a fluid tight metal-to-metal seal between interior surface of the tubular sleeve 2216 and the exterior surfaces of the end portions, 2214 and 2226, of the first and second tubular members. In this manner, fluidic materials are prevented from passing through the threaded connections, 2212 and 2224, of the first and second tubular members, 2210 and 2228, into the annulus between the first and second tubular members and the structure 2232. Furthermore, because, following the radial expansion and plastic deformation of the first and second tubular members, 2210 and 2228, the tubular sleeve 2216 may be maintained in circumferential tension and the end portions, 2214 and 2226, of the first and second tubular members, 2210 and 2228, may be maintained in circumferential compression, axial loads and/or torque loads may be transmitted through the tubular sleeve.

[000189] In several exemplary embodiments, one or more portions of the first and second tubular members, 2210 and 2228, and the tubular sleeve 2216 have one or more of the material properties of one or more of the tubular members 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204.

[000190] Referring to Fig. 23, in an exemplary embodiment, a first tubular member 2310 includes an internally threaded connection 2312 at an end portion 2314. A first end of a tubular sleeve 2316 includes an internal flange 2318 and a tapered portion 2320. A second end of the sleeve 2316 includes an internal flange 2321 and a tapered portion 2322. An externally threaded connection 2324 of an end portion 2326 of a second tubular member 2328 having an annular recess 2330, is then positioned within the tubular sleeve 2316 and threadably coupled to the internally threaded connection 2312 of the end portion 2314 of the first tubular member 2310. The internal flange 2318 of the sleeve 2316 mates with and is received

within the annular recess 2330.

[000191] The first tubular member 2310 includes a recess 2331. The internal flange 2321 mates with and is received within the annular recess 2331. Thus, the sleeve 2316 is coupled to and surrounds the external surfaces of the first and second tubular members 2310 and 2328.

[000192] The internally threaded connection 2312 of the end portion 2314 of the first tubular member 2310 is a box connection, and the externally threaded connection 2324 of the end portion 2326 of the second tubular member 2328 is a pin connection. In an exemplary embodiment, the internal diameter of the tubular sleeve 2316 is at least approximately .020" greater than the outside diameters of the first and second tubular members 2310 and 2328. In this manner, during the threaded coupling of the first and second tubular members 2310 and 2328, fluidic materials within the first and second tubular members may be vented from the tubular members.

[000193] As illustrated in Fig. 23, the first and second tubular members 2310 and 2328, and the tubular sleeve 2316 may then be positioned within another structure 2332 such as, for example, a wellbore, and radially expanded and plastically deformed, for example, by displacing and/or rotating an expansion device 2334 through and/or within the interiors of the first and second tubular members. The tapered portions 2320 and 2322, of the tubular sleeve 2316 facilitates the insertion and movement of the first and second tubular members within and through the structure 2332, and the displacement of the expansion device 2334 through the interiors of the first and second tubular members 2310 and 2328, may be from top to bottom or from bottom to top.

[000194] During the radial expansion and plastic deformation of the first and second tubular members 2310 and 2328, the tubular sleeve 2316 is also radially expanded and plastically deformed. In an exemplary embodiment, as a result, the tubular sleeve 2316 may be maintained in circumferential tension and the end portions 2314 and 2326, of the first and second tubular members 2310 and 2328, may be maintained in circumferential compression.

[000195] Sleeve 2316 increases the axial tension loading of the connection between tubular members 2310 and 2328 before and after expansion by the expansion device 2334. Sleeve 2316 may be secured to tubular members 2310 and 2328 by a heat shrink fit.

[000196] In several exemplary embodiments, one or more portions of the first and second tubular members, 2310 and 2328, and the tubular sleeve 2316 have one or more of the material properties of one or more of the tubular members 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204.

[000197] Referring to Fig. 24, in an exemplary embodiment, a first tubular member 2410 includes an internally threaded connection 2412 at an end portion 2414. A first end of a tubular sleeve 2416 includes an internal flange 2418 and a tapered portion 2420. A second end of the sleeve 2416 includes an internal flange 2421 and a tapered portion 2422. An externally threaded connection 2424 of an end portion 2426 of a second tubular member 2428 having an annular recess 2430, is then positioned within the tubular sleeve 2416 and threadably coupled to the internally threaded connection 2412 of the end portion 2414 of the first tubular member 2410. The internal flange 2418 of the sleeve 2416 mates with and is received

within the annular recess 2430. The first tubular member 2410 includes a recess 2431. The internal flange 2421 mates with and is received within the annular recess 2431. Thus, the sleeve 2416 is coupled to and surrounds the external surfaces of the first and second tubular members 2410 and 2428.

[000198] The internally threaded connection 2412 of the end portion 2414 of the first tubular member 2410 is a box connection, and the externally threaded connection 2424 of the end portion 2426 of the second tubular member 2428 is a pin connection. In an exemplary embodiment, the internal diameter of the tubular sleeve 2416 is at least approximately .020" greater than the outside diameters of the first and second tubular members 2410 and 2428. In this manner, during the threaded coupling of the first and second tubular members 2410 and 2428, fluidic materials within the first and second tubular members may be vented from the tubular members.

[000199] As illustrated in Fig. 24, the first and second tubular members 2410 and 2428, and the tubular sleeve 2416 may then be positioned within another structure 2432 such as, for example, a wellbore, and radially expanded and plastically deformed, for example, by displacing and/or rotating an expansion device 2434 through and/or within the interiors of the first and second tubular members. The tapered portions 2420 and 2422, of the tubular sleeve 2416 facilitate the insertion and movement of the first and second tubular members within and through the structure 2432, and the displacement of the expansion device 2434 through the interiors of the first and second tubular members, 2410 and 2428, may be from top to bottom or from bottom to top.

[000200] During the radial expansion and plastic deformation of the first and second tubular members, 2410 and 2428, the tubular sleeve 2416 is also radially expanded and plastically deformed. In an exemplary embodiment, as a result, the tubular sleeve 2416 may be maintained in circumferential tension and the end portions, 2414 and 2426, of the first and second tubular members, 2410 and 2428, may be maintained in circumferential compression.

[000201] The sleeve 2416 increases the axial compression and tension loading of the connection between tubular members 2410 and 2428 before and after expansion by expansion device 2424. Sleeve 2416 may be secured to tubular members 2410 and 2428 by a heat shrink fit.

[000202] In several exemplary embodiments, one or more portions of the first and second tubular members, 2410 and 2428, and the tubular sleeve 2416 have one or more of the material properties of one or more of the tubular members 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204.

[000203] Referring to Fig. 25, in an exemplary embodiment, a first tubular member 2510 includes an internally threaded connection 2512 at an end portion 2514. A first end of a tubular sleeve 2516 includes an internal flange 2518 and a relief 2520. A second end of the sleeve 2516 includes an internal flange 2521 and a relief 2522. An externally threaded connection 2524 of an end portion 2526 of a second tubular member 2528 having an annular recess 2530, is then positioned within the tubular sleeve 2516 and threadably coupled to the internally threaded connection 2512 of the end portion 2514 of the first tubular member 2510. The internal flange 2518 of the sleeve 2516 mates with and is received within the annular recess 2530. The first tubular member 2510 includes a recess 2531. The internal flange 2521

mates with and is received within the annular recess 2531. Thus, the sleeve 2516 is coupled to and surrounds the external surfaces of the first and second tubular members 2510 and 2528.

[000204] The internally threaded connection 2512 of the end portion 2514 of the first tubular member 2510 is a box connection, and the externally threaded connection 2524 of the end portion 2526 of the second tubular member 2528 is a pin connection. In an exemplary embodiment, the internal diameter of the tubular sleeve 2516 is at least approximately .020" greater than the outside diameters of the first and second tubular members 2510 and 2528. In this manner, during the threaded coupling of the first and second tubular members 2510 and 2528, fluidic materials within the first and second tubular members may be vented from the tubular members.

[000205] As illustrated in Fig. 25, the first and second tubular members 2510 and 2528, and the tubular sleeve 2516 may then be positioned within another structure 2532 such as, for example, a wellbore, and radially expanded and plastically deformed, for example, by displacing and/or rotating an expansion device 2534 through and/or within the interiors of the first and second tubular members. The reliefs 2520 and 2522 are each filled with a sacrificial material 2540 including a tapered surface 2542 and 2544, respectively. The material 2540 may be a metal or a synthetic, and is provided to facilitate the insertion and movement of the first and second tubular members 2510 and 2528, through the structure 2532. The displacement of the expansion device 2534 through the interiors of the first and second tubular members 2510 and 2528, may, for example, be from top to bottom or from bottom to top.

[000206] During the radial expansion and plastic deformation of the first and second tubular members 2510 and 2528, the tubular sleeve 2516 is also radially expanded and plastically deformed. In an exemplary embodiment, as a result, the tubular sleeve 2516 may be maintained in circumferential tension and the end portions 2514 and 2526, of the first and second tubular members, 2510 and 2528, may be maintained in circumferential compression.

[000207] The addition of the sacrificial material 2540, provided on sleeve 2516, avoids stress risers on the sleeve 2516 and the tubular member 2510. The tapered surfaces 2542 and 2544 are intended to wear or even become damaged, thus incurring such wear or damage which would otherwise be borne by sleeve 2516. Sleeve 2516 may be secured to tubular members 2510 and 2528 by a heat shrink fit.

[000208] In several exemplary embodiments, one or more portions of the first and second tubular members, 2510 and 2528, and the tubular sleeve 2516 have one or more of the material properties of one or more of the tubular members 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204.

[000209] Referring to Fig. 26, in an exemplary embodiment, a first tubular member 2610 includes an internally threaded connection 2612 at an end portion 2614. A first end of a tubular sleeve 2616 includes an internal flange 2618 and a tapered portion 2620. A second end of the sleeve 2616 includes an internal flange 2621 and a tapered portion 2622. An externally threaded connection 2624 of an end portion 2626 of a second tubular member 2628 having an annular recess 2630, is then positioned within the tubular sleeve 2616 and threadably coupled to the internally threaded connection 2612 of the end portion 2614 of the first tubular member 2610. The internal flange 2618 of the sleeve 2616 mates with and is received

within the annular recess 2630.

[000210] The first tubular member 2610 includes a recess 2631. The internal flange 2621 mates with and is received within the annular recess 2631. Thus, the sleeve 2616 is coupled to and surrounds the external surfaces of the first and second tubular members 2610 and 2628.

[000211] The internally threaded connection 2612 of the end portion 2614 of the first tubular member 2610 is a box connection, and the externally threaded connection 2624 of the end portion 2626 of the second tubular member 2628 is a pin connection. In an exemplary embodiment, the internal diameter of the tubular sleeve 2616 is at least approximately .020" greater than the outside diameters of the first and second tubular members 2610 and 2628. In this manner, during the threaded coupling of the first and second tubular members 2610 and 2628, fluidic materials within the first and second tubular members may be vented from the tubular members.

[000212] As illustrated in Fig. 26, the first and second tubular members 2610 and 2628, and the tubular sleeve 2616 may then be positioned within another structure 2632 such as, for example, a wellbore, and radially expanded and plastically deformed, for example, by displacing and/or rotating an expansion device 2634 through and/or within the interiors of the first and second tubular members. The tapered portions 2620 and 2622, of the tubular sleeve 2616 facilitates the insertion and movement of the first and second tubular members within and through the structure 2632, and the displacement of the expansion device 2634 through the interiors of the first and second tubular members 2610 and 2628, may, for example, be from top to bottom or from bottom to top.

[000213] During the radial expansion and plastic deformation of the first and second tubular members 2610 and 2628, the tubular sleeve 2616 is also radially expanded and plastically deformed. In an exemplary embodiment, as a result, the tubular sleeve 2616 may be maintained in circumferential tension and the end portions 2614 and 2626, of the first and second tubular members 2610 and 2628, may be maintained in circumferential compression.

[000214] Sleeve 2616 is covered by a thin walled cylinder of sacrificial material 2640. Spaces 2623 and 2624, adjacent tapered portions 2620 and 2622, respectively, are also filled with an excess of the sacrificial material 2640. The material may be a metal or a synthetic, and is provided to facilitate the insertion and movement of the first and second tubular members 2610 and 2628, through the structure 2632.

[000215] The addition of the sacrificial material 2640, provided on sleeve 2616, avoids stress risers on the sleeve 2616 and the tubular member 2610. The excess of the sacrificial material 2640 adjacent tapered portions 2620 and 2622 are intended to wear or even become damaged, thus incurring such wear or damage which would otherwise be borne by sleeve 2616. Sleeve 2616 may be secured to tubular members 2610 and 2628 by a heat shrink fit.

[000216] In several exemplary embodiments, one or more portions of the first and second tubular members, 2610 and 2628, and the tubular sleeve 2616 have one or more of the material properties of one or more of the tubular members 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204.

[000217] Referring to Fig. 27, in an exemplary embodiment, a first tubular member 2710 includes an internally threaded connection 2712 at an end portion 2714. A first end of a tubular sleeve 2716 includes an internal flange 2718 and a tapered portion 2720. A second end of the sleeve 2716 includes an internal flange 2721 and a tapered portion 2722. An externally threaded connection 2724 of an end portion 2726 of a second tubular member 2728 having an annular recess 2730, is then positioned within the tubular sleeve 2716 and threadably coupled to the internally threaded connection 2712 of the end portion 2714 of the first tubular member 2710. The internal flange 2718 of the sleeve 2716 mates with and is received within the annular recess 2730.

[000218] The first tubular member 2710 includes a recess 2731. The internal flange 2721 mates with and is received within the annular recess 2731. Thus, the sleeve 2716 is coupled to and surrounds the external surfaces of the first and second tubular members 2710 and 2728.

[000219] The internally threaded connection 2712 of the end portion 2714 of the first tubular member 2710 is a box connection, and the externally threaded connection 2724 of the end portion 2726 of the second tubular member 2728 is a pin connection. In an exemplary embodiment, the internal diameter of the tubular sleeve 2716 is at least approximately .020" greater than the outside diameters of the first and second tubular members 2710 and 2728. In this manner, during the threaded coupling of the first and second tubular members 2710 and 2728, fluidic materials within the first and second tubular members may be vented from the tubular members.

[000220] As illustrated in Fig. 27, the first and second tubular members 2710 and 2728, and the tubular sleeve 2716 may then be positioned within another structure 2732 such as, for example, a wellbore, and radially expanded and plastically deformed, for example, by displacing and/or rotating an expansion device 2734 through and/or within the interiors of the first and second tubular members. The tapered portions 2720 and 2722, of the tubular sleeve 2716 facilitates the insertion and movement of the first and second tubular members within and through the structure 2732, and the displacement of the expansion device 2734 through the interiors of the first and second tubular members 2710 and 2728, may be from top to bottom or from bottom to top.

[000221] During the radial expansion and plastic deformation of the first and second tubular members 2710 and 2728, the tubular sleeve 2716 is also radially expanded and plastically deformed. In an exemplary embodiment, as a result, the tubular sleeve 2716 may be maintained in circumferential tension and the end portions 2714 and 2726, of the first and second tubular members 2710 and 2728, may be maintained in circumferential compression.

[000222] Sleeve 2716 has a variable thickness due to one or more reduced thickness portions 2790 and/or increased thickness portions 2792.

[000223] Varying the thickness of sleeve 2716 provides the ability to control or induce stresses at selected positions along the length of sleeve 2716 and the end portions 2724 and 2726. Sleeve 2716 may be secured to tubular members 2710 and 2728 by a heat shrink fit.

[000224] In several exemplary embodiments, one or more portions of the first and second tubular

members, 2710 and 2728, and the tubular sleeve 2716 have one or more of the material properties of one or more of the tubular members 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204.

[000225] Referring to Fig. 28, in an alternative embodiment, instead of varying the thickness of sleeve 2716, the same result described above with reference to Fig. 27, may be achieved by adding a member 2740 which may be coiled onto the grooves 2739 formed in sleeve 2716, thus varying the thickness along the length of sleeve 2716.

[000226] Referring to Fig. 29, in an exemplary embodiment, a first tubular member 2910 includes an internally threaded connection 2912 and an internal annular recess 2914 at an end portion 2916. A first end of a tubular sleeve 2918 includes an internal flange 2920, and a second end of the sleeve 2916 mates with and receives the end portion 2916 of the first tubular member 2910. An externally threaded connection 2922 of an end portion 2924 of a second tubular member 2926 having an annular recess 2928, is then positioned within the tubular sleeve 2918 and threadably coupled to the internally threaded connection 2912 of the end portion 2916 of the first tubular member 2910. The internal flange 2920 of the sleeve 2918 mates with and is received within the annular recess 2928. A sealing element 2930 is received within the internal annular recess 2914 of the end portion 2916 of the first tubular member 2910.

[000227] The internally threaded connection 2912 of the end portion 2916 of the first tubular member 2910 is a box connection, and the externally threaded connection 2922 of the end portion 2924 of the second tubular member 2926 is a pin connection. In an exemplary embodiment, the internal diameter of the tubular sleeve 2918 is at least approximately .020" greater than the outside diameters of the first tubular member 2910. In this manner, during the threaded coupling of the first and second tubular members 2910 and 2926, fluidic materials within the first and second tubular members may be vented from the tubular members.

[000228] The first and second tubular members 2910 and 2926, and the tubular sleeve 2918 may be positioned within another structure such as, for example, a wellbore, and radially expanded and plastically deformed, for example, by displacing and/or rotating an expansion device through and/or within the interiors of the first and second tubular members.

[000229] During the radial expansion and plastic deformation of the first and second tubular members 2910 and 2926, the tubular sleeve 2918 is also radially expanded and plastically deformed. In an exemplary embodiment, as a result, the tubular sleeve 2918 may be maintained in circumferential tension and the end portions 2916 and 2924, of the first and second tubular members 2910 and 2926, respectively, may be maintained in circumferential compression.

[000230] In an exemplary embodiment, before, during, and after the radial expansion and plastic deformation of the first and second tubular members 2910 and 2926, and the tubular sleeve 2918, the sealing element 2930 seals the interface between the first and second tubular members. In an exemplary embodiment, during and after the radial expansion and plastic deformation of the first and second tubular members 2910 and 2926, and the tubular sleeve 2918, a metal to metal seal is formed between at least one of: the first and second tubular members 2910 and 2926, the first tubular member and the tubular

sleeve 2918, and/or the second tubular member and the tubular sleeve. In an exemplary embodiment, the metal to metal seal is both fluid tight and gas tight.

[000231] In several exemplary embodiments, one or more portions of the first and second tubular members, 2910 and 2926, the tubular sleeve 2918, and the sealing element 2930 have one or more of the material properties of one or more of the tubular members 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204.

[000232] Referring to Fig. 30a, in an exemplary embodiment, a first tubular member 3010 includes internally threaded connections 3012a and 3012b, spaced apart by a cylindrical internal surface 3014, at an end portion 3016. Externally threaded connections 3018a and 3018b, spaced apart by a cylindrical external surface 3020, of an end portion 3022 of a second tubular member 3024 are threadably coupled to the internally threaded connections, 3012a and 3012b, respectively, of the end portion 3016 of the first tubular member 3010. A sealing element 3026 is received within an annulus defined between the internal cylindrical surface 3014 of the first tubular member 3010 and the external cylindrical surface 3020 of the second tubular member 3024.

[000233] The internally threaded connections, 3012a and 3012b, of the end portion 3016 of the first tubular member 3010 are box connections, and the externally threaded connections, 3018a and 3018b, of the end portion 3022 of the second tubular member 3024 are pin connections. In an exemplary embodiment, the sealing element 3026 is an elastomeric and/or metallic sealing element.

[000234] The first and second tubular members 3010 and 3024 may be positioned within another structure such as, for example, a wellbore, and radially expanded and plastically deformed, for example, by displacing and/or rotating an expansion device through and/or within the interiors of the first and second tubular members.

[000235] In an exemplary embodiment, before, during, and after the radial expansion and plastic deformation of the first and second tubular members 3010 and 3024, the sealing element 3026 seals the interface between the first and second tubular members. In an exemplary embodiment, before, during and/or after the radial expansion and plastic deformation of the first and second tubular members 3010 and 3024, a metal to metal seal is formed between at least one of: the first and second tubular members 3010 and 3024, the first tubular member and the sealing element 3026, and/or the second tubular member and the sealing element. In an exemplary embodiment, the metal to metal seal is both fluid tight and gas tight.

[000236] In an alternative embodiment, the sealing element 3026 is omitted, and during and/or after the radial expansion and plastic deformation of the first and second tubular members 3010 and 3024, a metal to metal seal is formed between the first and second tubular members.

[000237] In several exemplary embodiments, one or more portions of the first and second tubular members, 3010 and 3024, the sealing element 3026 have one or more of the material properties of one or more of the tubular members 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204.

[000238] Referring to Fig. 30b, in an exemplary embodiment, a first tubular member 3030 includes

internally threaded connections 3032a and 3032b, spaced apart by an undulating approximately cylindrical internal surface 3034, at an end portion 3036. Externally threaded connections 3038a and 3038b, spaced apart by a cylindrical external surface 3040, of an end portion 3042 of a second tubular member 3044 are threadably coupled to the internally threaded connections, 3032a and 3032b, respectively, of the end portion 3036 of the first tubular member 3030. A sealing element 3046 is received within an annulus defined between the undulating approximately cylindrical internal surface 3034 of the first tubular member 3030 and the external cylindrical surface 3040 of the second tubular member 3044.

[000239] The internally threaded connections, 3032a and 3032b, of the end portion 3036 of the first tubular member 3030 are box connections, and the externally threaded connections, 3038a and 3038b, of the end portion 3042 of the second tubular member 3044 are pin connections. In an exemplary embodiment, the sealing element 3046 is an elastomeric and/or metallic sealing element.

[000240] The first and second tubular members 3030 and 3044 may be positioned within another structure such as, for example, a wellbore, and radially expanded and plastically deformed, for example, by displacing and/or rotating an expansion device through and/or within the interiors of the first and second tubular members.

[000241] In an exemplary embodiment, before, during, and after the radial expansion and plastic deformation of the first and second tubular members 3030 and 3044, the sealing element 3046 seals the interface between the first and second tubular members. In an exemplary embodiment, before, during and/or after the radial expansion and plastic deformation of the first and second tubular members 3030 and 3044, a metal to metal seal is formed between at least one of: the first and second tubular members 3030 and 3044, the first tubular member and the sealing element 3046, and/or the second tubular member and the sealing element. In an exemplary embodiment, the metal to metal seal is both fluid tight and gas tight.

[000242] In an alternative embodiment, the sealing element 3046 is omitted, and during and/or after the radial expansion and plastic deformation of the first and second tubular members 3030 and 3044, a metal to metal seal is formed between the first and second tubular members.

[000243] In several exemplary embodiments, one or more portions of the first and second tubular members, 3030 and 3044, the sealing element 3046 have one or more of the material properties of one or more of the tubular members 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204.

[000244] Referring to Fig. 30c, in an exemplary embodiment, a first tubular member 3050 includes internally threaded connections 3052a and 3052b, spaced apart by a cylindrical internal surface 3054 including one or more square grooves 3056, at an end portion 3058. Externally threaded connections 3060a and 3060b, spaced apart by a cylindrical external surface 3062 including one or more square grooves 3064, of an end portion 3066 of a second tubular member 3068 are threadably coupled to the internally threaded connections, 3052a and 3052b, respectively, of the end portion 3058 of the first tubular member 3050. A sealing element 3070 is received within an annulus defined between the

cylindrical internal surface 3054 of the first tubular member 3050 and the external cylindrical surface 3062 of the second tubular member 3068.

[000245] The internally threaded connections, 3052a and 3052b, of the end portion 3058 of the first tubular member 3050 are box connections, and the externally threaded connections, 3060a and 3060b, of the end portion 3066 of the second tubular member 3068 are pin connections. In an exemplary embodiment, the sealing element 3070 is an elastomeric and/or metallic sealing element.

[000246] The first and second tubular members 3050 and 3068 may be positioned within another structure such as, for example, a wellbore, and radially expanded and plastically deformed, for example, by displacing and/or rotating an expansion device through and/or within the interiors of the first and second tubular members.

[000247] In an exemplary embodiment, before, during, and after the radial expansion and plastic deformation of the first and second tubular members 3050 and 3068, the sealing element 3070 seals the interface between the first and second tubular members. In an exemplary embodiment, before, during and/or after the radial expansion and plastic deformation of the first and second tubular members, 3050 and 3068, a metal to metal seal is formed between at least one of: the first and second tubular members, the first tubular member and the sealing element 3070, and/or the second tubular member and the sealing element. In an exemplary embodiment, the metal to metal seal is both fluid tight and gas tight.

[000248] In an alternative embodiment, the sealing element 3070 is omitted, and during and/or after the radial expansion and plastic deformation of the first and second tubular members 3050 and 3068, a metal to metal seal is formed between the first and second tubular members.

[000249] In several exemplary embodiments, one or more portions of the first and second tubular members, 3050 and 3068, the sealing element 3070 have one or more of the material properties of one or more of the tubular members 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204.

[000250] Referring to Fig. 31, in an exemplary embodiment, a first tubular member 3110 includes internally threaded connections, 3112a and 3112b, spaced apart by a non-threaded internal surface 3114, at an end portion 3116. Externally threaded connections, 3118a and 3118b, spaced apart by a non-threaded external surface 3120, of an end portion 3122 of a second tubular member 3124 are threadably coupled to the internally threaded connections, 3112a and 3112b, respectively, of the end portion 3122 of the first tubular member 3124.

[000251] First, second, and/or third tubular sleeves, 3126, 3128, and 3130, are coupled to the external surface of the first tubular member 3110 in opposing relation to the threaded connection formed by the internal and external threads, 3112a and 3118a, the interface between the non-threaded surfaces, 3114 and 3120, and the threaded connection formed by the internal and external threads, 3112b and 3118b, respectively.

[000252] The internally threaded connections, 3112a and 3112b, of the end portion 3116 of the first tubular member 3110 are box connections, and the externally threaded connections, 3118a and 3118b, of the end portion 3122 of the second tubular member 3124 are pin connections.

[000253] The first and second tubular members 3110 and 3124, and the tubular sleeves 3126, 3128, and/or 3130, may then be positioned within another structure 3132 such as, for example, a wellbore, and radially expanded and plastically deformed, for example, by displacing and/or rotating an expansion device 3134 through and/or within the interiors of the first and second tubular members.

[000254] During the radial expansion and plastic deformation of the first and second tubular members 3110 and 3124, the tubular sleeves 3126, 3128 and/or 3130 are also radially expanded and plastically deformed. In an exemplary embodiment, as a result, the tubular sleeves 3126, 3128, and/or 3130 are maintained in circumferential tension and the end portions 3116 and 3122, of the first and second tubular members 3110 and 3124, may be maintained in circumferential compression.

[000255] The sleeves 3126, 3128, and/or 3130 may, for example, be secured to the first tubular member 3110 by a heat shrink fit.

[000256] In several exemplary embodiments, one or more portions of the first and second tubular members, 3110 and 3124, and the sleeves, 3126, 3128, and 3130, have one or more of the material properties of one or more of the tubular members 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204.

[000257] Referring to Fig. 32a, in an exemplary embodiment, a first tubular member 3210 includes an internally threaded connection 3212 at an end portion 3214. An externally threaded connection 3216 of an end portion 3218 of a second tubular member 3220 are threadably coupled to the internally threaded connection 3212 of the end portion 3214 of the first tubular member 3210.

[000258] The internally threaded connection 3212 of the end portion 3214 of the first tubular member 3210 is a box connection, and the externally threaded connection 3216 of the end portion 3218 of the second tubular member 3220 is a pin connection.

[000259] A tubular sleeve 3222 including internal flanges 3224 and 3226 is positioned proximate and surrounding the end portion 3214 of the first tubular member 3210.

[000260] As illustrated in Fig. 32b, the tubular sleeve 3222 is then forced into engagement with the external surface of the end portion 3214 of the first tubular member 3210 in a conventional manner. As a result, the end portions, 3214 and 3218, of the first and second tubular members, 3210 and 3220, are upset in an undulating fashion.

[000261] The first and second tubular members 3210 and 3220, and the tubular sleeve 3222, may then be positioned within another structure such as, for example, a wellbore, and radially expanded and plastically deformed, for example, by displacing and/or rotating an expansion device through and/or within the interiors of the first and second tubular members.

[000262] During the radial expansion and plastic deformation of the first and second tubular members 3210 and 3220, the tubular sleeve 3222 is also radially expanded and plastically deformed. In an exemplary embodiment, as a result, the tubular sleeve 3222 is maintained in circumferential tension and the end portions 3214 and 3218, of the first and second tubular members 3210 and 3220, may be maintained in circumferential compression.

[000263] In several exemplary embodiments, one or more portions of the first and second tubular

members, 3210 and 3220, and the sleeve 3222 have one or more of the material properties of one or more of the tubular members 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204.

[000264] Referring to Fig. 33, in an exemplary embodiment, a first tubular member 3310 includes an internally threaded connection 3312 and an annular projection 3314 at an end portion 3316.

[000265] A first end of a tubular sleeve 3318 that includes an internal flange 3320 having a tapered portion 3322 and an annular recess 3324 for receiving the annular projection 3314 of the first tubular member 3310, and a second end that includes a tapered portion 3326, is then mounted upon and receives the end portion 3316 of the first tubular member 3310.

[000266] In an exemplary embodiment, the end portion 3316 of the first tubular member 3310 abuts one side of the internal flange 3320 of the tubular sleeve 3318 and the annular projection 3314 of the end portion of the first tubular member mates with and is received within the annular recess 3324 of the internal flange of the tubular sleeve, and the internal diameter of the internal flange 3320 of the tubular sleeve 3318 is substantially equal to or greater than the maximum internal diameter of the internally threaded connection 3312 of the end portion 3316 of the first tubular member 3310. An externally threaded connection 3326 of an end portion 3328 of a second tubular member 3330 having an annular recess 3332 is then positioned within the tubular sleeve 3318 and threadably coupled to the internally threaded connection 3312 of the end portion 3316 of the first tubular member 3310. In an exemplary embodiment, the internal flange 3332 of the tubular sleeve 3318 mates with and is received within the annular recess 3332 of the end portion 3328 of the second tubular member 3330. Thus, the tubular sleeve 3318 is coupled to and surrounds the external surfaces of the first and second tubular members, 3310 and 3328.

[000267] The internally threaded connection 3312 of the end portion 3316 of the first tubular member 3310 is a box connection, and the externally threaded connection 3326 of the end portion 3328 of the second tubular member 3330 is a pin connection. In an exemplary embodiment, the internal diameter of the tubular sleeve 3318 is at least approximately .020" greater than the outside diameters of the first and second tubular members, 3310 and 3330. In this manner, during the threaded coupling of the first and second tubular members, 3310 and 3330, fluidic materials within the first and second tubular members may be vented from the tubular members.

[000268] As illustrated in Fig. 33, the first and second tubular members, 3310 and 3330, and the tubular sleeve 3318 may be positioned within another structure 3334 such as, for example, a cased or uncased wellbore, and radially expanded and plastically deformed, for example, by displacing and/or rotating a conventional expansion device 3336 within and/or through the interiors of the first and second tubular members. The tapered portions, 3322 and 3326, of the tubular sleeve 3318 facilitate the insertion and movement of the first and second tubular members within and through the structure 3334, and the movement of the expansion device 3336 through the interiors of the first and second tubular members, 3310 and 3330, may, for example, be from top to bottom or from bottom to top.

[000269] During the radial expansion and plastic deformation of the first and second tubular members,

3310 and 3330, the tubular sleeve 3318 is also radially expanded and plastically deformed. As a result, the tubular sleeve 3318 may be maintained in circumferential tension and the end portions, 3316 and 3328, of the first and second tubular members, 3310 and 3330, may be maintained in circumferential compression.

[000270] Sleeve 3316 increases the axial compression loading of the connection between tubular members 3310 and 3330 before and after expansion by the expansion device 3336. Sleeve 3316 may be secured to tubular members 3310 and 3330, for example, by a heat shrink fit.

[000271] In several alternative embodiments, the first and second tubular members, 3310 and 3330, are radially expanded and plastically deformed using other conventional methods for radially expanding and plastically deforming tubular members such as, for example, internal pressurization, hydroforming, and/or roller expansion devices and/or any one or combination of the conventional commercially available expansion products and services available from Baker Hughes, Weatherford International, and/or Enventure Global Technology L.L.C.

[000272] The use of the tubular sleeve 3318 during (a) the coupling of the first tubular member 3310 to the second tubular member 3330, (b) the placement of the first and second tubular members in the structure 3334, and (c) the radial expansion and plastic deformation of the first and second tubular members provides a number of significant benefits. For example, the tubular sleeve 3318 protects the exterior surfaces of the end portions, 3316 and 3328, of the first and second tubular members, 3310 and 3330, during handling and insertion of the tubular members within the structure 3334. In this manner, damage to the exterior surfaces of the end portions, 3316 and 3328, of the first and second tubular members, 3310 and 3330, is avoided that could otherwise result in stress concentrations that could cause a catastrophic failure during subsequent radial expansion operations. Furthermore, the tubular sleeve 3318 provides an alignment guide that facilitates the insertion and threaded coupling of the second tubular member 3330 to the first tubular member 3310. In this manner, misalignment that could result in damage to the threaded connections, 3312 and 3326, of the first and second tubular members, 3310 and 3330, may be avoided. In addition, during the relative rotation of the second tubular member with respect to the first tubular member, required during the threaded coupling of the first and second tubular members, the tubular sleeve 3318 provides an indication of to what degree the first and second tubular members are threadably coupled. For example, if the tubular sleeve 3318 can be easily rotated, that would indicate that the first and second tubular members, 3310 and 3330, are not fully threadably coupled and in intimate contact with the internal flange 3320 of the tubular sleeve. Furthermore, the tubular sleeve 3318 may prevent crack propagation during the radial expansion and plastic deformation of the first and second tubular members, 3310 and 3330. In this manner, failure modes such as, for example, longitudinal cracks in the end portions, 3316 and 3328, of the first and second tubular members may be limited in severity or eliminated all together. In addition, after completing the radial expansion and plastic deformation of the first and second tubular members, 3310 and 3330, the tubular sleeve 3318 may provide a fluid tight metal-to-metal seal between interior surface of the tubular sleeve 3318 and the

exterior surfaces of the end portions, 3316 and 3328, of the first and second tubular members. In this manner, fluidic materials are prevented from passing through the threaded connections, 3312 and 3326, of the first and second tubular members, 3310 and 3330, into the annulus between the first and second tubular members and the structure 3334. Furthermore, because, following the radial expansion and plastic deformation of the first and second tubular members, 3310 and 3330, the tubular sleeve 3318 may be maintained in circumferential tension and the end portions, 3316 and 3328, of the first and second tubular members, 3310 and 3330, may be maintained in circumferential compression, axial loads and/or torque loads may be transmitted through the tubular sleeve.

[000273] In several exemplary embodiments, one or more portions of the first and second tubular members, 3310 and 3330, and the sleeve 3318 have one or more of the material properties of one or more of the tubular members 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204.

[000274] Referring to Figs. 34a, 34b, and 34c, in an exemplary embodiment, a first tubular member 3410 includes an internally threaded connection 1312 and one or more external grooves 3414 at an end portion 3416.

[000275] A first end of a tubular sleeve 3418 that includes an internal flange 3420 and a tapered portion 3422, a second end that includes a tapered portion 3424, and an intermediate portion that includes one or more longitudinally aligned openings 3426, is then mounted upon and receives the end portion 3416 of the first tubular member 3410.

[000276] In an exemplary embodiment, the end portion 3416 of the first tubular member 3410 abuts one side of the internal flange 3420 of the tubular sleeve 3418, and the internal diameter of the internal flange 3420 of the tubular sleeve 3416 is substantially equal to or greater than the maximum internal diameter of the internally threaded connection 3412 of the end portion 3416 of the first tubular member 3410. An externally threaded connection 3428 of an end portion 3430 of a second tubular member 3432 that includes one or more internal grooves 3434 is then positioned within the tubular sleeve 3418 and threadably coupled to the internally threaded connection 3412 of the end portion 3416 of the first tubular member 3410. In an exemplary embodiment, the internal flange 3420 of the tubular sleeve 3418 mates with and is received within an annular recess 3436 defined in the end portion 3430 of the second tubular member 3432. Thus, the tubular sleeve 3418 is coupled to and surrounds the external surfaces of the first and second tubular members, 3410 and 3432.

[000277] The first and second tubular members, 3410 and 3432, and the tubular sleeve 3418 may be positioned within another structure such as, for example, a cased or uncased wellbore, and radially expanded and plastically deformed, for example, by displacing and/or rotating a conventional expansion device within and/or through the interiors of the first and second tubular members. The tapered portions, 3422 and 3424, of the tubular sleeve 3418 facilitate the insertion and movement of the first and second tubular members within and through the structure, and the movement of the expansion device through the interiors of the first and second tubular members, 3410 and 3432, may be from top to bottom or from bottom to top.

[000278] During the radial expansion and plastic deformation of the first and second tubular members, 3410 and 3432, the tubular sleeve 3418 is also radially expanded and plastically deformed. As a result, the tubular sleeve 3418 may be maintained in circumferential tension and the end portions, 3416 and 3430, of the first and second tubular members, 3410 and 3432, may be maintained in circumferential compression.

[000279] Sleeve 3416 increases the axial compression loading of the connection between tubular members 3410 and 3432 before and after expansion by the expansion device. The sleeve 3418 may be secured to tubular members 3410 and 3432, for example, by a heat shrink fit.

[000280] During the radial expansion and plastic deformation of the first and second tubular members, 3410 and 3432, the grooves 3414 and/or 3434 and/or the openings 3426 provide stress concentrations that in turn apply added stress forces to the mating threads of the threaded connections, 3412 and 3428. As a result, during and after the radial expansion and plastic deformation of the first and second tubular members, 3410 and 3432, the mating threads of the threaded connections, 3412 and 3428, are maintained in metal to metal contact thereby providing a fluid and gas tight connection. In an exemplary embodiment, the orientations of the grooves 3414 and/or 3434 and the openings 3426 are orthogonal to one another. In an exemplary embodiment, the grooves 3414 and/or 3434 are helical grooves.

[000281] In several alternative embodiments, the first and second tubular members, 3410 and 3432, are radially expanded and plastically deformed using other conventional methods for radially expanding and plastically deforming tubular members such as, for example, internal pressurization, hydroforming, and/or roller expansion devices and/or any one or combination of the conventional commercially available expansion products and services available from Baker Hughes, Weatherford International, and/or Enventure Global Technology L.L.C.

[000282] The use of the tubular sleeve 3418 during (a) the coupling of the first tubular member 3410 to the second tubular member 3432, (b) the placement of the first and second tubular members in the structure, and (c) the radial expansion and plastic deformation of the first and second tubular members provides a number of significant benefits. For example, the tubular sleeve 3418 protects the exterior surfaces of the end portions, 3416 and 3430, of the first and second tubular members, 3410 and 3432, during handling and insertion of the tubular members within the structure. In this manner, damage to the exterior surfaces of the end portions, 3416 and 3430, of the first and second tubular members, 3410 and 3432, is avoided that could otherwise result in stress concentrations that could cause a catastrophic failure during subsequent radial expansion operations. Furthermore, the tubular sleeve 3418 provides an alignment guide that facilitates the insertion and threaded coupling of the second tubular member 3432 to the first tubular member 3410. In this manner, misalignment that could result in damage to the threaded connections, 3412 and 3428, of the first and second tubular members, 3410 and 3432, may be avoided. In addition, during the relative rotation of the second tubular member with respect to the first tubular member, required during the threaded coupling of the first and second tubular members, the tubular sleeve 3416 provides an indication of to what degree the first and second tubular members are threadably

coupled. For example, if the tubular sleeve 3418 can be easily rotated, that would indicate that the first and second tubular members, 3410 and 3432, are not fully threadably coupled and in intimate contact with the internal flange 3420 of the tubular sleeve. Furthermore, the tubular sleeve 3418 may prevent crack propagation during the radial expansion and plastic deformation of the first and second tubular members, 3410 and 3432. In this manner, failure modes such as, for example, longitudinal cracks in the end portions, 3416 and 3430, of the first and second tubular members may be limited in severity or eliminated all together. In addition, after completing the radial expansion and plastic deformation of the first and second tubular members, 3410 and 3432, the tubular sleeve 3418 may provide a fluid and gas tight metal-to-metal seal between interior surface of the tubular sleeve 3418 and the exterior surfaces of the end portions, 3416 and 3430, of the first and second tubular members. In this manner, fluidic materials are prevented from passing through the threaded connections, 3412 and 3430, of the first and second tubular members, 3410 and 3432, into the annulus between the first and second tubular members and the structure. Furthermore, because, following the radial expansion and plastic deformation of the first and second tubular members, 3410 and 3432, the tubular sleeve 3418 may be maintained in circumferential tension and the end portions, 3416 and 3430, of the first and second tubular members, 3410 and 3432, may be maintained in circumferential compression, axial loads and/or torque loads may be transmitted through the tubular sleeve.

[000283] In several exemplary embodiments, the first and second tubular members described above with reference to Figs. 1 to 34c are radially expanded and plastically deformed using the expansion device in a conventional manner and/or using one or more of the methods and apparatus disclosed in one or more of the following: The present application is related to the following: (1) U.S. patent application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, (4) U.S. patent application serial no. 09/440,338, attorney docket no. 25791.9.02, filed on 11/15/1999, (5) U.S. patent application serial no. 09/523,460, attorney docket no. 25791.11.02, filed on 3/10/2000, (6) U.S. patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, (7) U.S. patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, (8) U.S. patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, (9) U.S. patent application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, (10) PCT patent application serial no. PCT/US00/18635, attorney docket no. 25791.25.02, filed on 7/9/2000, (11) U.S. provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (12) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (13) U.S. provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (14) U.S. provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (15) U.S. provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (16) U.S. provisional patent application serial no. 60/212,359, attorney

docket no. 25791.38, filed on 6/19/2000, (17) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (18) U.S. provisional patent application serial no. 60/221,443, attorney docket no. 25791.45, filed on 7/28/2000, (19) U.S. provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (20) U.S. provisional patent application serial no. 60/233,638, attorney docket no. 25791.47, filed on 9/18/2000, (21) U.S. provisional patent application serial no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, (22) U.S. provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on 2/20/2001, (23) U.S. provisional patent application serial no. 60/262,434, attorney docket no. 25791.51, filed on 1/17/2001, (24) U.S, provisional patent application serial no. 60/259,486, attorney docket no. 25791.52, filed on 1/3/2001, (25) U.S. provisional patent application serial no. 60/303,740, attorney docket no. 25791.61, filed on 7/6/2001, (26) U.S. provisional patent application serial no. 60/313,453, attorney docket no. 25791.59, filed on 8/20/2001, (27) U.S. provisional patent application serial no. 60/317,985, attorney docket no. 25791.67, filed on 9/6/2001, (28) U.S. provisional patent application serial no. 60/3318,386, attorney docket no. 25791.67.02, filed on 9/10/2001, (29) U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, (30) U.S. utility patent application serial no. 10/016,467, attorney docket no. 25791.70, filed on December 10, 2001, (31) U.S. provisional patent application serial no. 60/343,674, attorney docket no. 25791.68, filed on 12/27/2001; and (32) U.S. provisional patent application serial no. 60/346,309, attorney docket no. 25791.92, filed on 01/07/02, the disclosures of which are incorporated herein by reference.

[000284] Referring to Fig. 35a an exemplary embodiment of an expandable tubular member 3500 includes a first tubular region 3502 and a second tubular portion 3504. In an exemplary embodiment, the material properties of the first and second tubular regions, 3502 and 3504, are different. In an exemplary embodiment, the yield points of the first and second tubular regions, 3502 and 3504, are different. In an exemplary embodiment, the yield point of the first tubular region 3502 is less than the yield point of the second tubular region 3504. In several exemplary embodiments, one or more of the expandable tubular members, 12, 14, 24, 26, 102, 104, 106, 108, 202 and/or 204 incorporate the tubular member 3500.

[000285] Referring to Fig. 35b, in an exemplary embodiment, the yield point within the first and second tubular regions, 3502 and 3504, of the expandable tubular member 3500 vary as a function of the radial position within the expandable tubular member. In an exemplary embodiment, the yield point increases as a function of the radial position within the expandable tubular member 3500. In an exemplary embodiment, the relationship between the yield point and the radial position within the expandable tubular member 3500 is a linear relationship. In an exemplary embodiment, the relationship between the yield point and the radial position within the expandable tubular member 3500 is a non-linear relationship. In an exemplary embodiment, the yield point increases at different rates within the first and second tubular regions, 3502 and 3504, as a function of the radial position within the expandable tubular member 3502. In an exemplary embodiment, the functional relationship, and value, of the yield points within the first and second tubular regions, 3502 and 3504, of the expandable tubular member

3500 are modified by the radial expansion and plastic deformation of the expandable tubular member.

[000286] In several exemplary embodiments, one or more of the expandable tubular members, 12, 14, 24, 26, 102, 104, 106, 108, 202, 204 and/or 3502, prior to a radial expansion and plastic deformation, include a microstructure that is a combination of a hard phase, such as martensite, a soft phase, such as ferrite, and a transitionary phase, such as retained austentite. In this manner, the hard phase provides high strength, the soft phase provides ductility, and the transitionary phase transitions to a hard phase, such as martensite, during a radial expansion and plastic deformation. Furthermore, in this manner, the yield point of the tubular member increases as a result of the radial expansion and plastic deformation. Further, in this manner, the tubular member is ductile, prior to the radial expansion and plastic deformation, thereby facilitating the radial expansion and plastic deformation. In an exemplary embodiment, the composition of a dual-phase expandable tubular member includes (weight percentages): about 0.1% C, 1.2% Mn, and 0.3% Si.

[000287] In an exemplary experimental embodiment, as illustrated in Figs. 36a-36c, one or more of the expandable tubular members, 12, 14, 24, 26, 102, 104, 106, 108, 202, 204 and/or 3502 are processed in accordance with a method 3600, in which, in step 3602, an expandable tubular member 3602a is provided that is a steel alloy having following material composition (by weight percentage): 0.065% C, 1.44% Mn, 0.01% P, 0.002% S, 0.24% Si, 0.01% Cu, 0.01% Ni, 0.02% Cr, 0.05% V, 0.01%Mo, 0.01% Nb, and 0.01% Ti. In an exemplary experimental embodiment, the expandable tubular member 3602a provided in step 3602 has a yield strength of 45 ksi, and a tensile strength of 69 ksi.

[000288] In an exemplary experimental embodiment, as illustrated in Fig. 36b, in step 3602, the expandable tubular member 3602a includes a microstructure that includes martensite, pearlite, and V, Ni, and/or Ti carbides.

[000289] In an exemplary embodiment, the expandable tubular member 3602a is then heated at a temperature of 790 °C for about 10 minutes in step 3604.

[000290] In an exemplary embodiment, the expandable tubular member 3602a is then quenched in water in step 3606.

[000291] In an exemplary experimental embodiment, as illustrated in Fig. 36c, following the completion of step 3606, the expandable tubular member 3602a includes a microstructure that includes new ferrite, grain pearlite, martensite, and ferrite. In an exemplary experimental embodiment, following the completion of step 3606, the expandable tubular member 3602a has a yield strength of 67 ksi, and a tensile strength of 95 ksi.

[000292] In an exemplary embodiment, the expandable tubular member 3602a is then radially expanded and plastically deformed using one or more of the methods and apparatus described above. In an exemplary embodiment, following the radial expansion and plastic deformation of the expandable tubular member 3602a, the yield strength of the expandable tubular member is about 95 ksi.

[000293] In an exemplary experimental embodiment, as illustrated in Figs. 37a-37c, one or more of the expandable tubular members, 12, 14, 24, 26, 102, 104, 106, 108, 202, 204 and/or 3502 are processed in

accordance with a method 3700, in which, in step 3702, an expandable tubular member 3702a is provided that is a steel alloy having following material composition (by weight percentage): 0.18% C, 1.28% Mn, 0.017% P, 0.004% S, 0.29% Si, 0.01% Cu, 0.01% Ni, 0.03% Cr, 0.04% V, 0.01%Mo, 0.03% Nb, and 0.01% Ti. In an exemplary experimental embodiment, the expandable tubular member 3702a provided in step 3702 has a yield strength of 60 ksi, and a tensile strength of 80 ksi.

[000294] In an exemplary experimental embodiment, as illustrated in Fig. 37b, in step 3702, the expandable tubular member 3702a includes a microstructure that includes pearlite and pearlite striation.

[000295] In an exemplary embodiment, the expandable tubular member 3702a is then heated at a temperature of 790 °C for about 10 minutes in step 3704.

[000296] In an exemplary embodiment, the expandable tubular member 3702a is then quenched in water in step 3706.

[000297] In an exemplary experimental embodiment, as illustrated in Fig. 37c, following the completion of step 3706, the expandable tubular member 3702a includes a microstructure that includes ferrite, martensite, and bainite. In an exemplary experimental embodiment, following the completion of step 3706, the expandable tubular member 3702a has a yield strength of 82 ksi, and a tensile strength of 130 ksi.

[000298] In an exemplary embodiment, the expandable tubular member 3702a is then radially expanded and plastically deformed using one or more of the methods and apparatus described above. In an exemplary embodiment, following the radial expansion and plastic deformation of the expandable tubular member 3702a, the yield strength of the expandable tubular member is about 130 ksi.

[000299] In an exemplary experimental embodiment, as illustrated in Figs. 38a-38c, one or more of the expandable tubular members, 12, 14, 24, 26, 102, 104, 106, 108, 202, 204 and/or 3502 are processed in accordance with a method 3800, in which, in step 3802, an expandable tubular member 3802a is provided that is a steel alloy having following material composition (by weight percentage): 0.08% C, 0.82% Mn, 0.006% P, 0.003% S, 0.30% Si, 0.06% Cu, 0.05% Ni, 0.05% Cr, 0.03% V, 0.03%Mo, 0.01% Nb, and 0.01% Ti. In an exemplary experimental embodiment, the expandable tubular member 3802a provided in step 3802 has a yield strength of 56 ksi, and a tensile strength of 75 ksi.

[000300] In an exemplary experimental embodiment, as illustrated in Fig. 38b, in step 3802, the expandable tubular member 3802a includes a microstructure that includes grain pearlite, widmanstatten martensite and carbides of V, Ni, and/or Ti.

[000301] In an exemplary embodiment, the expandable tubular member 3802a is then heated at a temperature of 790 °C for about 10 minutes in step 3804.

[000302] In an exemplary embodiment, the expandable tubular member 3802a is then quenched in water in step 3806.

[000303] In an exemplary experimental embodiment, as illustrated in Fig. 38c, following the completion of step 3806, the expandable tubular member 3802a includes a microstructure that includes bainite, pearlite, and new ferrite. In an exemplary experimental embodiment, following the completion

of step 3806, the expandable tubular member 3802a has a yield strength of 60 ksi, and a tensile strength of 97 ksi.

[000304] In an exemplary embodiment, the expandable tubular member 3802a is then radially expanded and plastically deformed using one or more of the methods and apparatus described above. In an exemplary embodiment, following the radial expansion and plastic deformation of the expandable tubular member 3802a, the yield strength of the expandable tubular member is about 97 ksi.

[000305] In several exemplary embodiments, the teachings of the present disclosure are combined with one or more of the teachings disclosed in FR 2 841 626, filed on 6/28/2002, and published on 1/2/2004, the disclosure of which is incorporated herein by reference.

[000306] Referring to Figs. 39a-39f, an exemplary embodiment of an expansion system 3900 includes an adjustable expansion device 3902 and a hydroforming expansion device 3904 that are both coupled to a support member 3906.

[000307] In several exemplary embodiments, the adjustable expansion device 3902 includes one or more elements of conventional adjustable expansion devices and/or one or more elements of the adjustable expansion devices disclosed in one or more of the related applications referenced above and/or one or more elements of the conventional commercially available adjustable expansion devices available from Baker Hughes, Weatherford International, Schlumberger, and/or Enventure Global Technology L.L.C. In several exemplary embodiments, the hydroforming expansion device 3904 includes one or more elements of conventional hydroforming expansion devices and/or one or more elements of the hydroforming expansion devices disclosed in one or more of the related applications referenced above and/or one or more elements of the conventional commercially available hydroforming devices available from Baker Hughes, Weatherford International, Schlumberger, and/or Enventure Global Technology L.L.C. and/or one or more elements of the hydroforming expansion devices disclosed in U.S. Patent No. 5,901,594, the disclosure of which is incorporated herein by reference. In several exemplary embodiments, the adjustable expansion device 3902 and the hydroforming expansion device 3904 may be combined in a single device and/or include one or more elements of each other.

[000308] In an exemplary embodiment, during the operation of the expansion system 3900, as illustrated in Figs. 39a and 39b, the expansion system is positioned within an expandable tubular assembly that includes first and second tubular members, 3908 and 3910, that are coupled end to end and positioned and supported within a preexisting structure such as, for example, a wellbore 3912 that traverses a subterranean formation 3914. In several exemplary embodiments, the first and second tubular members, 3908 and 3910, include one or more of the characteristics of the expandable tubular members described in the present application.

[000309] In an exemplary embodiment, as illustrated in Fig. 39c, the hydroforming expansion device 3904 may then be operated to radially expand and plastically deform a portion of the second tubular member 3910.

[000310] In an exemplary embodiment, as illustrated in Fig. 39d, the hydroforming expansion device

3904 may then be disengaged from the second tubular member 3910.

[000311] In an exemplary embodiment, as illustrated in Fig. 39e, the adjustable expansion device 3902 may then be positioned within the radially expanded portion of the second tubular member 3910 and the size the adjustable expansion device increased.

[000312] In an exemplary embodiment, as illustrated in Fig. 39f, the adjustable expansion device 3902 may then be operated to radially expand and plastically deform one or more portions of the first and second tubular members, 3908 and 3910.

[000313] Referring to Figs. 40a-40g, an exemplary embodiment of an expansion system 4000 includes a hydroforming expansion device 4002 that is coupled to a support member 4004.

[000314] In several exemplary embodiments, the hydroforming expansion device 4002 includes one or more elements of conventional hydroforming expansion devices and/or one or more elements of the hydroforming expansion devices disclosed in one or more of the related applications referenced above and/or one or more elements of the conventional commercially available hydroforming devices available from Baker Hughes, Weatherford International, Schlumberger, and/or Enventure Global Technology L.L.C. and/or one or more elements of the hydroforming expansion devices disclosed in U.S. Patent No. 5,901,594, the disclosure of which is incorporated herein by reference.

[000315] In an exemplary embodiment, during the operation of the expansion system 4000, as illustrated in Figs. 40a and 40b, the expansion system is positioned within an expandable tubular assembly that includes first and second tubular members, 4006 and 4008, that are coupled end to end and positioned and supported within a preexisting structure such as, for example, a wellbore 4010 that traverses a subterranean formation 4012. In several exemplary embodiments, the first and second tubular members, 4004 and 4006, include one or more of the characteristics of the expandable tubular members described in the present application.

[000316] In an exemplary embodiment, as illustrated in Figs. 40c to 40f, the hydroforming expansion device 4002 may then be repeatedly operated to radially expand and plastically deform one or more portions of the first and second tubular members, 4008 and 4010.

[000317] Referring to Figs. 41a-41h, an exemplary embodiment of an expansion system 4100 includes an adjustable expansion device 4102 and a hydroforming expansion device 4104 that are both coupled to a tubular support member 4106.

[000318] In several exemplary embodiments, the adjustable expansion device 4102 includes one or more elements of conventional adjustable expansion devices and/or one or more elements of the adjustable expansion devices disclosed in one or more of the related applications referenced above and/or one or more elements of the conventional commercially available adjustable expansion devices available from Baker Hughes, Weatherford International, Schlumberger, and/or Enventure Global Technology L.L.C. In several exemplary embodiments, the hydroforming expansion device 4104 includes one or more elements of conventional hydroforming expansion devices and/or one or more elements of the hydroforming expansion devices disclosed in one or more of the related applications referenced above

and/or one or more elements of the conventional commercially available hydroforming devices available from Baker Hughes, Weatherford International, Schlumberger, and/or Enventure Global Technology L.L.C. and/or one or more elements of the hydroforming expansion devices disclosed in U.S. Patent No. 5,901,594, the disclosure of which is incorporated herein by reference. In several exemplary embodiments, the adjustable expansion device 4102 and the hydroforming expansion device 4104 may be combined in a single device and/or include one or more elements of each other.

[000319] In an exemplary embodiment, during the operation of the expansion system 4100, as illustrated in Figs. 41a and 41b, the expansion system is positioned within an expandable tubular assembly that includes first and second tubular members, 4108 and 4110, that are coupled end to end and positioned and supported within a preexisting structure such as, for example, a wellbore 4112 that traverses a subterranean formation 4114. In an exemplary embodiment, a shoe 4116 having a valveable passage 4118 is coupled to the lower portion of the second tubular member 4110. In several exemplary embodiments, the first and second tubular members, 4108 and 4110, include one or more of the characteristics of the expandable tubular members described in the present application.

[000320] In an exemplary embodiment, as illustrated in Fig. 41c, the hydroforming expansion device 4104 may then be operated to radially expand and plastically deform a portion of the second tubular member 4110.

[000321] In an exemplary embodiment, as illustrated in Fig. 41d, the hydroforming expansion device 4104 may then be disengaged from the second tubular member 4110.

[000322] In an exemplary embodiment, as illustrated in Figs. 41e and 41f, the adjustable expansion device 4102 may then be positioned within the radially expanded portion of the second tubular member 4110 and the size the adjustable expansion device increased. The valveable passage 4118 of the shoe 4116 may then be closed, for example, by placing a ball 4120 within the passage in a conventional manner.

[000323] In an exemplary embodiment, as illustrated in Fig. 41g, the adjustable expansion device 4102 may then be operated to radially expand and plastically deform one or more portions of the first and second tubular members, 4108 and 4110, above the shoe 4116.

[000324] In an exemplary embodiment, as illustrated in Fig. 41h, the expansion system 4100 may then be removed from the tubular assembly and the lower, radially unexpanded, portion of the second tubular member 4110 and the shoe 4116 may be machined away.

[000325] Referring to Figs. 42a-42e, an exemplary embodiment of an expansion system 4200 includes a hydroforming expansion device 4202 that is coupled to a tubular support member 4204. An expandable tubular member 4206 is coupled to and supported by the hydroforming expansion device 4202.

[000326] In several exemplary embodiments, the hydroforming expansion device 4202 includes one or more elements of conventional hydroforming expansion devices and/or one or more elements of the hydroforming expansion devices disclosed in one or more of the related applications referenced above

and/or one or more elements of the conventional commercially available hydroforming devices available from Baker Hughes, Weatherford International, Schlumberger, and/or Enventure Global Technology L.L.C. and/or one or more elements of the hydroforming expansion devices disclosed in U.S. Patent No. 5,901,594, the disclosure of which is incorporated herein by reference.

[000327] In several exemplary embodiments, the expandable tubular member 4206 includes one or more of the characteristics of the expandable tubular members described in the present application.

[000328] In an exemplary embodiment, during the operation of the expansion system 4200, as illustrated in Figs. 42a and 42b, the expansion system is positioned within an expandable tubular assembly that includes first and second tubular members, 4208 and 4210, that are coupled end to end and positioned and supported within a preexisting structure such as, for example, a wellbore 4212 that traverses a subterranean formation 4214. In an exemplary embodiment, the second tubular member 4210 includes one or more radial passages 4212. In an exemplary embodiment, the expandable tubular member 4206 is positioned in opposing relation to the radial passages 4212 of the second tubular member 4210.

[000329] In an exemplary embodiment, as illustrated in Fig. 42c, the hydroforming expansion device 4202 may then be operated to radially expand and plastically deform the expandable tubular member 4206 into contact with the interior surface of the second tubular member 4210 thereby covering and sealing off the radial passages 4212 of the second tubular member.

[000330] In an exemplary embodiment, as illustrated in Fig. 42d, the hydroforming expansion device 4202 may then be disengaged from the expandable tubular member 4206.

[000331] In an exemplary embodiment, as illustrated in Figs. 42e, the expansion system 4200 may then be removed from the wellbore 4212.

[000332] Referring to Fig. 43, an exemplary embodiment of a hydroforming expansion system 4300 includes an expansion element 4302 that is provided substantially as disclosed in U.S. Patent No. 5,901,594, the disclosure of which is incorporated herein by reference.

[000333] A flow line 4304 is coupled to the inlet of the expansion element 4302 and the outlet of conventional 2-way/2-position flow control valve 4306. A flow line 4308 is coupled to an inlet of the flow control valve 4306 and an outlet of a conventional accumulator 4310, and a flow line 4312 is coupled to another inlet of the flow control valve and a fluid reservoir 4314.

[000334] A flow line 4316 is coupled to the flow line 4308 and an inlet of a conventional pressure relief valve 4318, and a flow line 4320 is coupled to the outlet of the pressure relief valve and the fluid reservoir 4314. A flow line 4322 is coupled to the inlet of the accumulator 4310 and the outlet of a conventional check valve 4324.

[000335] A flow line 4326 is coupled to the inlet of the check valve 4324 and the outlet of a conventional pump 4328. A flow line 4330 is coupled to the flow line 4326 and the inlet of a conventional pressure relief valve 4332.

[000336] A flow line 4334 is coupled to the outlet of the pressure relief valve 4332 and the fluid

reservoir 4314, and a flow line 4336 is coupled to the inlet of the pump 4328 and the fluid reservoir.

[000337] A controller 4338 is operably coupled to the flow control valve 4306 and the pump 4328 for controlling the operation of the flow control valve and the pump. In an exemplary embodiment, the controller 4338 is a programmable general purpose controller. Conventional pressure sensors, 4340, 4342 and 4344, are operably coupled to the expansion element 4302, the accumulator 4310, and the flow line 4326, respectively, and the controller 4338. A conventional user interface 4346 is operably coupled to the controller 4338.

[000338] During operation of the hydroforming expansion system 4300, as illustrated in Figs. 44a-44b, the system implements a method of operation 4400 in which, in step 4402, the user may select expansion of an expandable tubular member. If the user selects expansion in step 4402, then the controller 4338 determines if the operating pressure of the accumulator 4310, as sensed by the pressure sensor 4342, is greater than or equal to a predetermined value in step 4404.

[000339] If the operating pressure of the accumulator 4310, as sensed by the pressure sensor 4342, is not greater than or equal to the predetermined value in step 4404, then the controller 4338 operates the pump 4328 to increase the operating pressure of the accumulator in step 4406. The controller 4338 then determines if the operating pressure of the accumulator 4310, as sensed by the pressure sensor 4342, is greater than or equal to a predetermined value in step 4408. If the operating pressure of the accumulator 4310, as sensed by the pressure sensor 4342, in step 4408, is not greater than or equal to the predetermined value, then the controller 4338 continues to operate the pump 4328 to increase the operating pressure of the accumulator in step 4406.

[000340] If the operating pressure of the accumulator 4310, as sensed by the pressure sensor 4342, in steps 4404 or 4408, is greater than or equal to the predetermined value, then the controller 4338 operates the flow control valve 4306 to pressurize the expansion element 4302 in step 4410 by positioning the flow control valve to couple the flow lines 4304 and 4308 to one another. If the expansion operation has been completed in step 4412, then the controller 4338 operates the flow control valve 4306 to de-pressurize the expansion element 4302 in step 4414 by positioning the flow control valve to couple the flow lines 4304 and 4312 to one another.

[000341] In several exemplary embodiments, one or more of the hydroforming expansion devices 4002, 4104, and 4202, incorporate one or more elements of the hydroforming expansion system 4300 and/or the operational steps of the method 4400.

[000342] Referring to Fig. 45a, an exemplary embodiment of a liner hanger system 4500 includes a tubular support member 4502 that defines a passage 4502a and includes an externally threaded connection 4502b at an end. An internally threaded connection 4504a of an end of an outer tubular mandrel 4504 that defines a passage 4504b, and includes an external flange 4504c, an internal annular recess 4504d, an external annular recess 4504e, an external annular recess 4504f, an external flange 4504g, an external annular recess 4504h, an internal flange 4504i, an external flange 4504j, and a plurality of circumferentially spaced apart longitudinally aligned teeth 4504k at another end, is coupled to

and receives the externally threaded connection 4502b of the end of the tubular support member 4502.

[000343] An end of a tubular liner hanger 4506 that abuts and mates with an end face of the external flange 4504c of the outer tubular mandrel 4504 receives and mates with the outer tubular mandrel, and includes internal teeth 4506a, a plurality of circumferentially spaced apart longitudinally aligned internal teeth 4506b, an internal flange 4506c, and an external threaded connection 4506d at another end. In an exemplary embodiment, at least a portion of the tubular liner hanger 4506 includes one or more of the characteristics of the expandable tubular members described in the present application.

[000344] An internal threaded connection 4508a of an end of a tubular liner 4508 receives and is coupled to the external threaded connection 4506d of the tubular liner hanger 4506. Spaced apart elastomeric sealing elements, 4510, 4512, and 4514, are coupled to the exterior surface of the end of the tubular liner hanger 4506

[000345] An external flange 4516a of an end of an inner tubular mandrel 4516 that defines a longitudinal passage 4516b having a throat 4516ba and a radial passage 4516c and includes a sealing member 4516d mounted upon the external flange for sealingly engaging the inner annular recess 4504d of the outer tubular mandrel 4504, an external flange 4516e at another end that includes a plurality of circumferentially spaced apart teeth 4516f that mate with and engage the teeth, 4504k and 4506b, of the outer tubular mandrel 4504 and the tubular liner hanger 4506, respectively, for transmitting torsional loads therebetween, and another end that is received within and mates with the internal flange 4506c of the tubular liner hanger 4506 mates with and is received within the inner annular recess 4504d of the outer tubular mandrel 4504. A conventional rupture disc 4518 is received within and coupled to the radial passage 4516c of the inner tubular mandrel 4516.

[000346] A conventional packer cup 4520 is mounted within and coupled to the external annular recess 4504e of the outer tubular mandrel 4504 for sealingly engaging the interior surface of the tubular liner hanger 4506. A locking assembly 4522 is mounted upon and coupled to the outer tubular mandrel 4504 proximate the external flange 4504g in opposing relation to the internal teeth 4506a of the tubular liner hanger 4506 for controllably engaging and locking the position of the tubular liner hanger relative to the outer tubular mandrel 4504. In several exemplary embodiments, the locking assembly 4522 may be a conventional locking device for locking the position of a tubular member relative to another member. In several alternative embodiments, the locking assembly 4522 may include one or more elements of the locking assemblies disclosed in one or more of the following: (1) PCT patent application serial number PCT/US02/36157, attorney docket number 25791.87.02, filed on 11/12/2002, (2) PCT patent application serial number PCT/US02/36267, attorney docket number 25791.88.02, filed on 11/12/2002, (3) PCT patent application serial number PCT/US03/04837, attorney docket number 25791.95.02, filed on 2/29/2003, (4) PCT patent application serial number PCT/US03/29859, attorney docket no. 25791.102.02, filed on 9/22/2003, (5) PCT patent application serial number PCT/US03/14153, attorney docket number 25791.104.02, filed on 11/13/2003, (6) PCT patent application serial number PCT/US03/18530, attorney docket number 25791.108.02, filed on 6/11/2003, (7) PCT patent application

serial number PCT/US03/29858, attorney docket number 25791.112.02, (8) PCT patent application serial number PCT/US03/29460, attorney docket number 25791.114.02, filed on 9/23/2003, filed on 9/22/2003, (9) PCT patent application serial number PCT/US04/07711, attorney docket number 25791.253.02, filed on 3/11/2004, (10) PCT patent application serial number PCT/US2004/009434, attorney docket number 25791.260.02, filed on 3/26/2004, (11) PCT patent application serial number PCT/US2004/010317, attorney docket number 25791.270.02, filed on 4/2/2004, (12) PCT patent application serial number PCT/US2004/010712, attorney docket number 25791.272.02, filed on 4/7/2004, (13) PCT patent application serial number PCT/US2004/010762, attorney docket number 25791.273.02, filed on 4/6/2004, and/or (14) PCT patent application serial number PCT/US2004/011973, attorney docket number 25791.277.02, filed on April 15, 2004, the disclosures of which are incorporated herein by reference.

[000347] An adjustable expansion device assembly 4524 is mounted upon and coupled to the outer tubular mandrel 4504 between the locking assembly 4522 and the external flange 4504j for controllably radially expanding and plastically deforming the tubular liner hanger 4506. In several exemplary embodiments, the adjustable expansion device assembly 4524 may be a conventional adjustable expansion device assembly for radially expanding and plastically deforming tubular members that may include one or more elements of conventional adjustable expansion cones, mandrels, rotary expansion devices, hydroforming expansion devices and/or one or more elements of the one or more of the commercially available adjustable expansion devices of Enventure Global Technology LLC, Baker Hughes, Weatherford International, and/or Schlumberger and/or one or more elements of the adjustable expansion devices disclosed in one or more of the published patent applications and/or issued patents of Enventure Global Technology LLC, Baker Hughes, Weatherford International, Shell Oil Co. and/or Schlumberger. In several alternative embodiments, the adjustable expansion device assembly 4524 may include one or more elements of the adjustable expansion device assemblies disclosed in one or more of the following: (1) PCT patent application serial number PCT/US02/36157, attorney docket number 25791.87.02, filed on 11/12/2002, (2) PCT patent application serial number PCT/US02/36267, attorney docket number 25791.88.02, filed on 11/12/2002, (3) PCT patent application serial number PCT/US03/04837, attorney docket number 25791.95.02, filed on 2/29/2003, (4) PCT patent application serial number PCT/US03/29859, attorney docket no. 25791.102.02, filed on 9/22/2003, (5) PCT patent application serial number PCT/US03/14153, attorney docket number 25791.104.02, filed on 11/13/2003, (6) PCT patent application serial number PCT/US03/18530, attorney docket number 25791.108.02, filed on 6/11/2003, (7) PCT patent application serial number PCT/US03/29858, attorney docket number 25791.112.02, (8) PCT patent application serial number PCT/US03/29460, attorney docket number 25791.114.02, filed on 9/23/2003, filed on 9/22/2003, (9) PCT patent application serial number PCT/US04/07711, attorney docket number 25791.253.02, filed on 3/11/2004, (10) PCT patent application serial number PCT/US2004/009434, attorney docket number 25791.260.02, filed on 3/26/2004, (11) PCT patent application serial number PCT/US2004/010317, attorney docket number

25791.270.02, filed on 4/2/2004, (12) PCT patent application serial number PCT/US2004/010712, attorney docket number 25791.272.02, filed on 4/7/2004, (13) PCT patent application serial number PCT/US2004/010762, attorney docket number 25791.273.02, filed on 4/6/2004, and/or (14) PCT patent application serial number PCT/US2004/011973, attorney docket number 25791.277.02, filed on April 15, 2004, the disclosures of which are incorporated herein by reference.

[000348] A conventional SSR plug set 4526 is mounted within and coupled to the internal flange 4506c of the tubular liner hanger 4506.

[000349] In an exemplary embodiment, during operation of the system 4500, as illustrated in Fig. 45a, the system is positioned within a wellbore 4528 that traverses a subterranean formation 4530 and includes a preexisting wellbore casing 4532 coupled to and positioned within the wellbore. In an exemplary embodiment, the system 4500 is positioned such that the tubular liner hanger 4506 overlaps with the casing 4532.

[000350] Referring to Fig. 45b, in an exemplary embodiment, a ball 4534 is then positioned in the throat passage 4516ba by injecting fluidic materials 4536 into the system 4500 through the passages 4502a, 4504b, and 4516b, of the tubular support member 4502, outer tubular mandrel 4504, and inner tubular mandrel 4516, respectively.

[000351] Referring to Fig. 45c, in an exemplary embodiment, the continued injection of the fluidic materials 4536 into the system 4500, following the placement of the ball 4534 in the throat passage 4516ba, pressurizes the passage 4516b of the inner tubular mandrel 4516 such that the rupture disc 4518 is ruptured thereby permitting the fluidic materials to pass through the radial passage 4516c of the inner tubular mandrel. As a result, the interior of the tubular liner hanger 4506 is pressurized.

[000352] Referring to Fig. 45d, in an exemplary embodiment, the continued injection of the fluidic materials 4536 into the interior of the tubular liner hanger 4506 radially expands and plastically deforms at least a portion of the tubular liner hanger. In an exemplary embodiment, the continued injection of the fluidic materials 4536 into the interior of the tubular liner hanger 4506 radially expands and plastically deforms a portion of the tubular liner hanger positioned in opposition to the adjustable expansion device assembly 4524. In an exemplary embodiment, the continued injection of the fluidic materials 4536 into the interior of the tubular liner hanger 4506 radially expands and plastically deforms a portion of the tubular liner hanger positioned in opposition to the adjustable expansion device assembly 4524 into engagement with the wellbore casing 4532.

[000353] Referring to Fig. 45e, in an exemplary embodiment, the size of the adjustable expansion device assembly 4524 is then increased within the radially expanded portion of the tubular liner hanger 4506, and the locking assembly 4522 is operated to unlock the tubular liner hanger from engagement with the locking assembly. In an exemplary embodiment, the locking assembly 4522 and the adjustable expansion device assembly 4524 are operated using the operating pressure provided by the continued injection of the fluidic materials 4536 into the system 4500. In an exemplary embodiment, the adjustment of the adjustable expansion device assembly 4524 to a larger size radially expands and

plastically deforms at least a portion of the tubular liner hanger 4506.

[000354] Referring to Fig. 45f, in an exemplary embodiment, the adjustable expansion device assembly 4524 is displaced in a longitudinal direction relative to the tubular liner hanger 4506 thereby radially expanding and plastically deforming the tubular liner hanger. In an exemplary embodiment, the tubular liner hanger 4506 is radially expanded and plastically deformed into engagement with the casing 4532. In an exemplary embodiment, the adjustable expansion device assembly 4524 is displaced in a longitudinal direction relative to the tubular liner hanger 4506 due to the operating pressure within the tubular liner hanger generated by the continued injection of the fluidic materials 4536. In an exemplary embodiment, the adjustable expansion device assembly 4524 is displaced in a longitudinal direction relative to the tubular liner hanger 4506 due to the operating pressure within the tubular liner hanger below the packer cup 4520 generated by the continued injection of the fluidic materials 4536. In this manner, the adjustable expansion device assembly 4524 is pulled through the tubular liner hanger 4506 by the operation of the packer cup 4520. In an exemplary embodiment, the adjustable expansion device assembly 4524 is displaced in a longitudinal direction relative to the tubular liner hanger 4506 thereby radially expanding and plastically deforming the tubular liner hanger until the internal flange 4504i of the outer tubular mandrel 4504 engages the external flange 4516a of the end of the inner tubular mandrel 4516.

[000355] Referring to Fig. 45g, in an exemplary embodiment, the 4504, due to the engagement of the internal flange 4504i of the outer tubular mandrel 4504 with the external flange 4516a of the end of the inner tubular mandrel 4516, the inner tubular mandrel and the SSR plug set 4526 may be removed from the wellbore 4528. As a result, the tubular liner 4508 is suspended within the wellbore 4528 by virtue of the engagement of the tubular liner hanger 4506 with the wellbore casing 4532.

[000356] In several alternative embodiments, during the operation of the system 4500, a hardenable fluidic sealing material such as, for example, cement, may injected through the system 4500 before, during or after the radial expansion of the liner hanger 4506 in order to form an annular barrier between the wellbore 4528 and the tubular liner 4508.

[000357] In several alternative embodiments, during the operation of the system 4500, the size of the adjustable expansion device 4524 is increased prior to, during, or after the hydroforming expansion of the tubular liner hanger 4506 caused by the injection of the fluidic materials 4536 into the interior of the tubular liner hanger.

[000358] In several alternative embodiments, at least a portion of the tubular liner hanger 4506 includes a plurality of nested expandable tubular members bonded together by, for example, amorphous bonding.

[000359] In several alternative embodiments, at least a portion of the tubular liner hanger 4506 is fabricated from materials particularly suited for subsequent drilling out operations such as, for example, aluminum and/or copper based materials and alloys.

[000360] In several alternative embodiments, during the operation of the system 4500, the portion of

the tubular liner hanger 4506 positioned below the adjustable expansion device 4524 is radially expanded and plastically deformed by displacing the adjustable expansion device downwardly.

[000361] In several alternative embodiments, at least a portion of the tubular liner hanger 4506 is fabricated from materials particularly suited for subsequent drilling out operations such as, for example, aluminum and/or copper based materials and alloys. In several alternative embodiments, during the operation of the system 4500, the portion of the tubular liner hanger 4506 fabricated for materials particularly suited for subsequent drilling out operations is not hydroformed by the injection of the fluidic materials 4536.

[000362] In several alternative embodiments, during the operation of the system 4500, at least a portion of the tubular liner hanger 4506 is hydroformed by the injection of the fluidic materials 4536, the remaining portion of the tubular liner hanger above the initial position of the adjustable expansion device 4524 is then radially expanded and plastically deformed by displacing the adjustable expansion device upwardly, and the portion of the tubular liner hanger below the initial position of the adjustable expansion device is radially expanded by then displacing the adjustable expansion device downwardly.

[000363] In several alternative embodiments, during the operation of the system 4500, the portion of the tubular liner hanger 4506 that is radially expanded and plastically deformed is radially expanded and plastically deformed solely by hydroforming caused by the injection of the fluidic materials 4536.

[000364] In several alternative embodiments, during the operation of the system 4500, the portion of the tubular liner hanger 4506 that is radially expanded and plastically deformed is radially expanded and plastically deformed solely by the adjustment of the adjustable expansion device 4524 to an increased size and the subsequent displacement of the adjustable expansion device relative to the tubular liner hanger.

[000365] Referring to Fig. 46a, an exemplary embodiment of a system 4600 for radially expanding a tubular member includes a tubular support member 4602 that defines a passage 4602a. An end of a conventional tubular safety sub 4604 that defines a passage 4604a is coupled to an end of the tubular support member 4602, and another end of the safety sub 4604 is coupled to an end of a tubular casing lock assembly 4606 that defines a passage 4606a.

[000366] In several exemplary embodiments, the lock assembly 4606 may be a conventional locking device for locking the position of a tubular member relative to another member. In several alternative embodiments, the lock assembly 4606 may include one or more elements of the locking assemblies disclosed in one or more of the following: (1) PCT patent application serial number PCT/US02/36157, attorney docket number 25791.87.02, filed on 11/12/2002, (2) PCT patent application serial number PCT/US02/36267, attorney docket number 25791.88.02, filed on 11/12/2002, (3) PCT patent application serial number PCT/US03/04837, attorney docket number 25791.95.02, filed on 2/29/2003, (4) PCT patent application serial number PCT/US03/29859, attorney docket no. 25791.102.02, filed on 9/22/2003, (5) PCT patent application serial number PCT/US03/14153, attorney docket number 25791.104.02, filed on 11/13/2003, (6) PCT patent application serial number PCT/US03/18530, attorney

docket number 25791.108.02, filed on 6/11/2003, (7) PCT patent application serial number PCT/US03/29858, attorney docket number 25791.112.02, (8) PCT patent application serial number PCT/US03/29460, attorney docket number 25791.114.02, filed on 9/23/2003, filed on 9/22/2003, (9) PCT patent application serial number PCT/US04/07711, attorney docket number 25791.253.02, filed on 3/11/2004, (10) PCT patent application serial number PCT/US2004/009434, attorney docket number 25791.260.02, filed on 3/26/2004, (11) PCT patent application serial number PCT/US2004/010317, attorney docket number 25791.270.02, filed on 4/2/2004, (12) PCT patent application serial number PCT/US2004/010712, attorney docket number 25791.272.02, filed on 4/7/2004, (13) PCT patent application serial number PCT/US2004/010762, attorney docket number 25791.273.02, filed on 4/6/2004, and/or (14) PCT patent application serial number PCT/US2004/011973, attorney docket number 25791.277.02, filed on April 15, 2004, the disclosures of which are incorporated herein by reference.

[000367] A end of a tubular support member 4608 that defines a passage 4608a and includes an outer annular recess 4608b is coupled to another end of the lock assembly 4606, and another end of the tubular support member 4608 is coupled to an end of a tubular support member 4610 that defines a passage 4610a, a radial passage 4610b, and includes an outer annular recess 4610c, an inner annular recess 4610d, and circumferentially spaced apart teeth 4610e at another end.

[000368] An adjustable expansion device assembly 4612 is mounted upon and coupled to the outer annular recess 4610c of the tubular support member 4610. In several exemplary embodiments, the adjustable expansion device assembly 4612 may be a conventional adjustable expansion device assembly for radially expanding and plastically deforming tubular members that may include one or more elements of conventional adjustable expansion cones, mandrels, rotary expansion devices, hydroforming expansion devices and/or one or more elements of the one or more of the commercially available adjustable expansion devices of Enventure Global Technology LLC, Baker Hughes, Weatherford International, and/or Schlumberger and/or one or more elements of the adjustable expansion devices disclosed in one or more of the published patent applications and/or issued patents of Enventure Global Technology LLC, Baker Hughes, Weatherford International, Shell Oil Co. and/or Schlumberger. In several alternative embodiments, the adjustable expansion device assembly 4524 may include one or more elements of the adjustable expansion device assemblies disclosed in one or more of the following: (1) PCT patent application serial number PCT/US02/36157, attorney docket number 25791.87.02, filed on 11/12/2002, (2) PCT patent application serial number PCT/US02/36267, attorney docket number 25791.88.02, filed on 11/12/2002, (3) PCT patent application serial number PCT/US03/04837, attorney docket number 25791.95.02, filed on 2/29/2003, (4) PCT patent application serial number PCT/US03/29859, attorney docket no. 25791.102.02, filed on 9/22/2003, (5) PCT patent application serial number PCT/US03/14153, attorney docket number 25791.104.02, filed on 11/13/2003, (6) PCT patent application serial number PCT/US03/18530, attorney docket number 25791.108.02, filed on 6/11/2003, (7) PCT patent application serial number PCT/US03/29858, attorney docket number 25791.112.02, (8) PCT patent application serial

number PCT/US03/29460, attorney docket number 25791.114.02, filed on 9/23/2003, filed on 9/22/2003, (9) PCT patent application serial number PCT/US04/07711, attorney docket number 25791.253.02, filed on 3/11/2004, (10) PCT patent application serial number PCT/US2004/009434, attorney docket number 25791.260.02, filed on 3/26/2004, (11) PCT patent application serial number PCT/US2004/010317, attorney docket number 25791.270.02, filed on 4/2/2004, (12) PCT patent application serial number PCT/US2004/010712, attorney docket number 25791.272.02, filed on 4/7/2004, (13) PCT patent application serial number PCT/US2004/010762, attorney docket number 25791.273.02, filed on 4/6/2004, and/or (14) PCT patent application serial number PCT/US2004/011973, attorney docket number 25791.277.02, filed on April 15, 2004, the disclosures of which are incorporated herein by reference.

[000369] An end of a float shoe 4614 that defines a passage 4614a having a throat 4614aa and includes a plurality of circumferentially spaced apart teeth 4614b at an end that mate with and engage the teeth 4610e of the tubular support member 4610 for transmitting torsional loads therebetween and an external threaded connection 4614c is received within the inner annular recess 4610d of the tubular support member.

[000370] An end of an expandable tubular member 4616 is coupled to the external threaded connection 4614c of the float shoe 4614 and another portion of the expandable tubular member is coupled to the lock assembly 4606. In an exemplary embodiment, at least a portion of the expandable tubular member 4616 includes one or more of the characteristics of the expandable tubular members described in the present application. In an exemplary embodiment, the portion of the expandable tubular member 4616 proximate and positioned in opposition to the adjustable expansion device assembly 4612 includes an outer expansion limiter sleeve 4618 for limiting the amount of radial expansion of the portion of the expandable tubular member proximate and positioned in opposition to the adjustable expansion device assembly. In an exemplary embodiment, at least a portion of the outer expansion limiter sleeve 4618 includes one or more of the characteristics of the expandable tubular members described in the present application.

[000371] A cup seal assembly 4620 is coupled to and positioned within the outer annular recess 4608b of the tubular support member 4608 for sealingly engaging the interior surface of the expandable tubular member 4616. A rupture disc 4622 is positioned within and coupled to the radial passage 4610b of the tubular support member 4610.

[000372] In an exemplary embodiment, during operation of the system 4600, as illustrated in Fig. 46a, the system is positioned within a wellbore 4624 that traverses a subterranean formation 4626 and includes a preexisting wellbore casing 4628 coupled to and positioned within the wellbore. In an exemplary embodiment, the system 4600 is positioned such that the expandable tubular member 4616 overlaps with the casing 4628.

[000373] Referring to Fig. 46b, in an exemplary embodiment, a plug 4630 is then positioned in the throat passage 4614aa of the float shoe 4614 by injecting fluidic materials 4632 into the system 4600

through the passages 4602a, 4604a, 4606a, 4608a, and 4610a, of the tubular support member 4602, safety sub 4604, lock assembly 4606, tubular support member 4608, and tubular support member 4610, respectively.

[000374] Referring to Fig. 46c, in an exemplary embodiment, the continued injection of the fluidic materials 4632 into the system 4600, following the placement of the plug 4630 in the throat passage 4614aa, pressurizes the passage 4610a of the tubular support member 4610 such that the rupture disc 4622 is ruptured thereby permitting the fluidic materials to pass through the radial passage 4610b of the tubular support member. As a result, the interior of the expandable tubular member 4616 proximate the adjustable expansion device assembly 4612 is pressurized.

[000375] Referring to Fig. 46d, in an exemplary embodiment, the continued injection of the fluidic materials 4632 into the interior of the expandable tubular member 4616 radially expands and plastically deforms at least a portion of the expandable tubular member. In an exemplary embodiment, the continued injection of the fluidic materials 4632 into the interior of the expandable tubular member 4616 radially expands and plastically deforms a portion of the expandable tubular member positioned in opposition to the adjustable expansion device assembly 4612. In an exemplary embodiment, the continued injection of the fluidic materials 4632 into the interior of the expandable tubular member 4616 radially expands and plastically deforms a portion of the expandable tubular member positioned in opposition to the adjustable expansion device assembly 4612 into engagement with the wellbore casing 4628. In an exemplary embodiment, the transformation of the material properties of the expansion limiter sleeve 4618, during the radial expansion process, limit the extent to which the expandable tubular member 4616 may be radially expanded.

[000376] Referring to Fig. 46e, in an exemplary embodiment, the size of the adjustable expansion device assembly 4612 is then increased within the radially expanded portion of the expandable tubular member 4616, and the lock assembly 4606 is operated to unlock the expandable tubular member from engagement with the lock assembly. In an exemplary embodiment, the lock assembly 4606 and the adjustable expansion device assembly 4612 are operated using the operating pressure provided by the continued injection of the fluidic materials 4632 into the system 4600. In an exemplary embodiment, the adjustment of the adjustable expansion device assembly 4612 to a larger size radially expands and plastically deforms at least a portion of the expandable tubular member 4616.

[000377] Referring to Fig. 46f, in an exemplary embodiment, the adjustable expansion device assembly 4612 is displaced in a longitudinal direction relative to the expandable tubular member 4616 thereby radially expanding and plastically deforming the expandable tubular member. In an exemplary embodiment, the expandable tubular member 4616 is radially expanded and plastically deformed into engagement with the casing 4628. In an exemplary embodiment, the adjustable expansion device assembly 4612 is displaced in a longitudinal direction relative to the expandable tubular member 4616 due to the operating pressure within the expandable tubular member generated by the continued injection of the fluidic materials 4632.

[000378] In several alternative embodiments, during the operation of the system 4600, a hardenable fluidic sealing material such as, for example, cement, may injected through the system 4600 before, during or after the radial expansion of the expandable tubular member 4616 in order to form an annular barrier between the wellbore 4624 and/or the wellbore casing 4628 and the expandable tubular member.

[000379] In several alternative embodiments, during the operation of the system 4600, the size of the adjustable expansion device 4612 is increased prior to, during, or after the hydroforming expansion of the expandable tubular member 4616 caused by the injection of the fluidic materials 4632 into the interior of the expandable tubular member.

[000380] In several alternative embodiments, at least a portion of the expandable tubular member 4616 includes a plurality of nested expandable tubular members bonded together by, for example, amorphous bonding.

[000381] In several alternative embodiments, at least a portion of the expandable tubular member 4616 is fabricated from materials particularly suited for subsequent drilling out operations such as, for example, aluminum and/or copper based materials and alloys.

[000382] In several alternative embodiments, during the operation of the system 4600, the portion of the expandable tubular member 4616 positioned below the adjustable expansion device 4612 is radially expanded and plastically deformed by displacing the adjustable expansion device downwardly.

[000383] In several alternative embodiments, at least a portion of the expandable tubular member 4616 is fabricated from materials particularly suited for subsequent drilling out operations such as, for example, aluminum and/or copper based materials and alloys. In several alternative embodiments, during the operation of the system 4600, the portion of the expandable tubular member 4616 fabricated for materials particularly suited for subsequent drilling out operations is not hydroformed by the injection of the fluidic materials 4632.

[000384] In several alternative embodiments, during the operation of the system 4600, at least a portion of the expandable tubular member 4616 is hydroformed by the injection of the fluidic materials 4632, the remaining portion of the expandable tubular member above the initial position of the adjustable expansion device 4612 is then radially expanded and plastically deformed by displacing the adjustable expansion device upwardly, and the portion of the expandable tubular member below the initial position of the adjustable expansion device is radially expanded by then displacing the adjustable expansion device downwardly.

[000385] In several alternative embodiments, during the operation of the system 4600, the portion of the expandable tubular member 4616 that is radially expanded and plastically deformed is radially expanded and plastically deformed solely by hydroforming caused by the injection of the fluidic materials 4632.

[000386] In several alternative embodiments, during the operation of the system 4600, the portion of the expandable tubular member 4616 that is radially expanded and plastically deformed is radially expanded and plastically deformed solely by the adjustment of the adjustable expansion device 4612 to

an increased size and the subsequent displacement of the adjustable expansion device relative to the expandable tubular member.

[000387] In an exemplary experimental embodiment, expandable tubular members fabricated from tellurium copper, leaded naval brass, phosphorous bronze, and aluminum-silicon bronze were successfully hydroformed and thereby radially expanded and plastically deformed by up to about 30% radial expansion, all of which were unexpected results.

[000388] Referring to Fig. 46g, in an exemplary embodiment, at least a portion of the expansion limiter sleeve 4618, prior to the radial expansion and plastic deformation of the expansion limiter sleeve by operation of the system 4600, includes one or more diamond shaped slots 4618a. Referring to Fig. 46h, in an exemplary embodiment, during the radial expansion and plastic deformation of the expansion limiter sleeve by operation of the system 4600, the diamond shaped slots 4618a are deformed such that further radial expansion of the expansion limiter sleeve requires increased force. More generally, the expansion limiter sleeve 4618 may be manufactured with slots whose cross sectional areas are decreased by the radial expansion and plastic deformation of the expansion limited sleeve thereby increasing the amount of force required to further radially expand the expansion limiter sleeve. In this manner, the extent to which the expandable tubular member 4616 may be radially expanded is limited. In several alternative embodiments, at least a portion of the expandable tubular member 4616 includes slots whose cross sectional areas are decreased by the radial expansion and plastic deformation of the expandable tubular member thereby increasing the amount of force required to further radially expand the expandable tubular member.

[000389] Referring to Figs. 46i and 46ia, in an exemplary embodiment, at least a portion of the expansion limiter sleeve 4618, prior to the radial expansion and plastic deformation of the expansion limiter sleeve by operation of the system 4600, includes one or more wavy circumferentially oriented spaced apart bands 4618b. Referring to Fig. 46j, in an exemplary embodiment, during the radial expansion and plastic deformation of the expansion limiter sleeve by operation of the system 4600, the bands 4618b are deformed such that the further radial expansion of the expansion limiter sleeve requires added force. More generally, the expansion limiter sleeve 4618 may be manufactured with a circumferential bands whose orientation becomes more and more aligned with a direction that is orthogonal to the longitudinal axis of the sectional areas as a result of the radial expansion and plastic deformation of the bands thereby increasing the amount of force required to further radially expand the expansion limiter sleeve. In this manner, the extent to which the expandable tubular member 4616 may be radially expanded is limited. In several alternative embodiments, at least a portion of the expandable tubular member 4616 includes circumferential bands whose orientation becomes more and more aligned with a direction that is orthogonal to the longitudinal axis of the sectional areas as a result of the radial expansion and plastic deformation of the bands thereby increasing the amount of force required to further radially expand the expandable tubular member.

[000390] In several exemplary embodiments, the design of the expansion limiter sleeve 4618 provides

a restraining force that limits the extent to which the expandable tubular member 4616 may be radially expanded and plastically deformed. Furthermore, in several exemplary embodiments, the design of the expansion limiter sleeve 4618 provides a variable restraining force that limits the extent to which the expandable tubular member 4616 may be radially expanded and plastically deformed. In several exemplary embodiments, the variable restraining force of the expansion limiter sleeve 4618 increases in proportion to the degree to which the expandable tubular member 4616 has been radially expanded.

[000391] Referring to Fig. 47a, an exemplary embodiment of a system 4700 for radially expanding a tubular member includes a tubular support member 4702 that defines a passage 4702a. An end of a conventional tubular safety sub 4704 that defines a passage 4704a is coupled to an end of the tubular support member 4702, and another end of the safety sub 4704 is coupled to an end of a tubular ball gripper assembly 4706 that defines a passage 4706a.

[000392] In several exemplary embodiments, the ball gripper assembly 4706 may be a conventional device for limiting movement of tubular member relative to another member that employs, for example, one or more separate discrete ball-like elements to controllably engage and limit relative movement of the tubular member in one or more directions. In several alternative embodiments, the ball gripper assembly 4706 may include one or more elements of the ball grabber assemblies disclosed in one or more of the following: (1) PCT patent application serial number PCT/US02/36157, attorney docket number 25791.87.02, filed on 11/12/2002, (2) PCT patent application serial number PCT/US02/36267, attorney docket number 25791.88.02, filed on 11/12/2002, (3) PCT patent application serial number PCT/US03/04837, attorney docket number 25791.95.02, filed on 2/29/2003, (4) PCT patent application serial number PCT/US03/29859, attorney docket no. 25791.102.02, filed on 9/22/2003, (5) PCT patent application serial number PCT/US03/14153, attorney docket number 25791.104.02, filed on 11/13/2003, (6) PCT patent application serial number PCT/US03/18530, attorney docket number 25791.108.02, filed on 6/11/2003, (7) PCT patent application serial number PCT/US03/29858, attorney docket number 25791.112.02, (8) PCT patent application serial number PCT/US03/29460, attorney docket number 25791.114.02, filed on 9/23/2003, filed on 9/22/2003, (9) PCT patent application serial number PCT/US04/07711, attorney docket number 25791.253.02, filed on 3/11/2004, (10) PCT patent application serial number PCT/US2004/009434, attorney docket number 25791.260.02, filed on 3/26/2004, (11) PCT patent application serial number PCT/US2004/010317, attorney docket number 25791.270.02, filed on 4/2/2004, (12) PCT patent application serial number PCT/US2004/010712, attorney docket number 25791.272.02, filed on 4/7/2004, (13) PCT patent application serial number PCT/US2004/010762, attorney docket number 25791.273.02, filed on 4/6/2004, and/or (14) PCT patent application serial number PCT/US2004/011973, attorney docket number 25791.277.02, filed on April 15, 2004, the disclosures of which are incorporated herein by reference.

[000393] An end of a tubular casing lock assembly 4708 that defines a passage 4708a is coupled to the other end of the ball gripper assembly 4706. In several exemplary embodiments, the casing lock assembly 4708 may be a conventional device for limiting movement of a tubular member relative to

another member. In several alternative embodiments, the casing lock assembly 4708 may include one or more elements of the casing lock assemblies disclosed in one or more of the following: (1) PCT patent application serial number PCT/US02/36157, attorney docket number 25791.87.02, filed on 11/12/2002, (2) PCT patent application serial number PCT/US02/36267, attorney docket number 25791.88.02, filed on 11/12/2002, (3) PCT patent application serial number PCT/US03/04837, attorney docket number 25791.95.02, filed on 2/29/2003, (4) PCT patent application serial number PCT/US03/29859, attorney docket no. 25791.102.02, filed on 9/22/2003, (5) PCT patent application serial number PCT/US03/14153, attorney docket number 25791.104.02, filed on 11/13/2003, (6) PCT patent application serial number PCT/US03/18530, attorney docket number 25791.108.02, filed on 6/11/2003, (7) PCT patent application serial number PCT/US03/29858, attorney docket number 25791.112.02, (8) PCT patent application serial number PCT/US03/29460, attorney docket number 25791.114.02, filed on 9/23/2003, filed on 9/22/2003, (9) PCT patent application serial number PCT/US04/07711, attorney docket number 25791.253.02, filed on 3/11/2004, (10) PCT patent application serial number PCT/US2004/009434, attorney docket number 25791.260.02, filed on 3/26/2004, (11) PCT patent application serial number PCT/US2004/010317, attorney docket number 25791.270.02, filed on 4/2/2004, (12) PCT patent application serial number PCT/US2004/010712, attorney docket number 25791.272.02, filed on 4/7/2004, (13) PCT patent application serial number PCT/US2004/010762, attorney docket number 25791.273.02, filed on 4/6/2004, and/or (14) PCT patent application serial number PCT/US2004/011973, attorney docket number 25791.277.02, filed on April 15, 2004, the disclosures of which are incorporated herein by reference.

[000394] An end of a tubular tension actuator assembly 4710 that defines a passage 4710a and one or more external mounting holes 4710b and includes an internal annular recess 4710c at one end is coupled to the other end of the casing lock assembly 4708. In several exemplary embodiments, the tubular tension actuator assembly 4710 may be a conventional device for displacing a member relative to another member. In several alternative embodiments, the tubular tension actuator assembly 4710 may include one or more elements of the tension actuator assemblies disclosed in one or more of the following: (1) PCT patent application serial number PCT/US02/36157, attorney docket number 25791.87.02, filed on 11/12/2002, (2) PCT patent application serial number PCT/US02/36267, attorney docket number 25791.88.02, filed on 11/12/2002, (3) PCT patent application serial number PCT/US03/04837, attorney docket number 25791.95.02, filed on 2/29/2003, (4) PCT patent application serial number PCT/US03/29859, attorney docket no. 25791.102.02, filed on 9/22/2003, (5) PCT patent application serial number PCT/US03/14153, attorney docket number 25791.104.02, filed on 11/13/2003, (6) PCT patent application serial number PCT/US03/18530, attorney docket number 25791.108.02, filed on 6/11/2003, (7) PCT patent application serial number PCT/US03/29858, attorney docket number 25791.112.02, (8) PCT patent application serial number PCT/US03/29460, attorney docket number 25791.114.02, filed on 9/23/2003, filed on 9/22/2003, (9) PCT patent application serial number PCT/US04/07711, attorney docket number 25791.253.02, filed on 3/11/2004, (10) PCT patent

application serial number PCT/US2004/009434, attorney docket number 25791.260.02, filed on 3/26/2004, (11) PCT patent application serial number PCT/US2004/010317, attorney docket number 25791.270.02, filed on 4/2/2004, (12) PCT patent application serial number PCT/US2004/010712, attorney docket number 25791.272.02, filed on 4/7/2004, (13) PCT patent application serial number PCT/US2004/010762, attorney docket number 25791.273.02, filed on 4/6/2004, and/or (14) PCT patent application serial number PCT/US2004/011973, attorney docket number 25791.277.02, filed on April 15, 2004, the disclosures of which are incorporated herein by reference.

[000395] A primary solid tubular expansion cone 4712 that includes a tapered external surface 4712a at one end 4712b is coupled to the other end of the tubular tension actuator assembly 4710. An expandable tubular casing 4714 that defines one or more mounting holes 4714a at one end receives and mates with the safety sub 4704, ball gripper assembly 4706, casing lock assembly 4708, tension actuator assembly 4710. The end of the tubular casing 4714 receives and mates with the non-tapered end and a portion of the tapered end 4712b of the tubular expansion cone 4712. As a result, the end of the tubular casing 4714 that receives and mates with the portion of the tapered end 4712b of the tubular expansion cone 4712 is flared. In an exemplary embodiment, the outside diameter of the flared tapered end of the tubular casing 4714 is less than or equal to the maximum outside diameter of the tapered end 4712b of the tubular expansion cone 4712. An end of a mounting pin 4716 is received within and coupled to the mounting hole 4710b of the tension actuator assembly 4710, and another end of the mounting pin is received within and coupled to the mounting hole 4714a of the tubular casing 4714. In an exemplary embodiment, the expandable tubular casing 4714 is provided and includes one or more of the properties of the expandable tubulars described above with reference to Figs. 1 to 46j. In an exemplary embodiment, during the operation of the system 4700, the mounting pin 4716 permits torque to be transmitted between the expandable tubular casing 4714 and the tension actuator assembly 4710.

[000396] An end of a secondary tubular expansion cone 4718 that defines a passage 4718a and includes an external annular recess 4718b, that mates with and is received within the end of the tension actuator assembly 4710 and the primary tubular expansion cone 4712, and a tapered external surface 4718c, an internal annular recess 4718d, and a plurality of circumferentially spaced apart teeth 4718e at another end is coupled to the end of the tension actuator assembly 4710. An expandable tubular sleeve 4720 that includes a first end 4720a including an external annular recess 4720aa, an intermediate portion 4720b, and a second end 4720c having an internal threaded connection 4720d mates with and receives the secondary tubular expansion cone 4718. In an exemplary embodiment, the expandable tubular sleeve 4720 is provided and includes one or more of the properties of the expandable tubulars described above with reference to Figs. 1 to 46j. A sealing member 4722 is received within and coupled to the external annular recess 4720aa of the first end 4720a of the expandable tubular sleeve 4720. In an exemplary embodiment, the wall thickness of the first end 4720a of the tubular sleeve 4720 is greater than the wall thickness of the second end 4720c of the tubular sleeve, and the wall thickness of the intermediate portion 4720b of the tubular sleeve is tapered. In an exemplary embodiment, the outside diameter of the

intermediate portion 4720b and the second end 4720c of the tubular sleeve 4720 are both less than or equal to the maximum outside diameter of the tapered end 4712b of the tubular expansion cone 4712. In an exemplary embodiment, the outside diameter of the sealing member 4722 is less than or equal to the maximum outside diameter of the tapered end 4712b of the tubular expansion cone 4712.

[000397] A float shoe 4724 that defines a passage 4724a having a throat 4724aa and a passage 4724b and includes an external annular recess 4724c at one end that is received within and mates with the internal annular recess 4718d of the end of the secondary tubular expansion cone 4718, a plurality of circumferentially spaced apart shoulders 4724d at another end, a plurality of circumferentially spaced apart teeth 4724e for engaging the circumferentially spaced apart teeth 4718e of the secondary tubular expansion cone 4718, and a conventional float element 4724f is received within, mates with, and is coupled to the internal threaded connection 4720d of the end of the expandable tubular sleeve 4720. In an exemplary embodiment, the outside diameter of the spaced apart shoulders 4724d of the float shoe 4724 are greater than the outside diameter of the maximum outside diameter of the tapered end 4712b of the tubular expansion cone 4712. In an exemplary embodiment, during the operation of the system 4700, the interaction of the circumferentially spaced apart teeth 4724e of the float shoe 4724 with the circumferentially spaced apart teeth 4718e of the secondary tubular expansion cone 4718 permits torque loads to be transmitted there between. In an exemplary embodiment, during the operation of the system 4700, the circumferentially spaced apart shoulders 4724d further define circumferentially spaced apart axial flow passages there between.

[000398] In an exemplary embodiment, during operation of the system 4700, as illustrated in Fig. 47a, the system is positioned within a wellbore 4726 that traverses a subterranean formation 4728. A hardenable fluidic sealing material 4730 such as, for example, cement may then be injected into the system 4700 through the passages 4702a, 4704a, 4706a, 4708a, 4710a, 4718a, and 4724a. The fluidic material 4730 may then be conveyed past the float element 4724f of the float shoe 4724 and through the passage 4724b into an annulus 4732 between the system 4700 and the interior surface of the wellbore 4726. The fluidic material 4730 within the annulus 4732 may then be allowed to at least partially cure.

[000399] In an exemplary embodiment, during the operation of the system 4700, as illustrated in Fig. 47b, a conventional plug 4734 is then positioned within the throat 4724aa of the passage 4724a of the float shoe 4724 by injecting fluidic material 4736 into the system 4700 through the passages 4702a, 4704a, 4706a, 4708a, 4710a, 4718a, and 4724a. As a result, the passage 4724a of the float shoe 4724 is blocked and the passages 4702a, 4704a, 4706a, 4708a, 4710a, and 4718a may be pressurized by the continued injection of the fluidic material 4736.

[000400] In an exemplary embodiment, during the operation of the system 4700, as illustrated in Fig. 47c, the passages 4702a, 4704a, 4706a, 4708a, 4710a, and 4718a may be pressurized by the continued injection of the fluidic material 4736 into the system. As a result, the casing lock assembly 4708 is operated to engage the expandable tubular casing 4714 and the tension actuator assembly 4710 is operated to displace the primary tubular expansion cone 4712, secondary tubular expansion cone 4718,

expandable tubular sleeve 4720, sealing member 4722, and float shoe 4724 upwardly in a longitudinal direction 4738 relative to the expandable tubular casing 4714. As a result, the end of the expandable tubular casing 4714 is radially expanded and plastically deformed by the tapered external surface 4712a of the primary tubular expansion cone 4712. Furthermore, as a result, the radially expanded and plastically deformed end of the tubular casing 4714 receives and mates with the expandable tubular sleeve 4720 and the sealing member 4722. Furthermore, as a result, the mounting pin 4716 is sheared. In an exemplary embodiment, the end of the expandable tubular casing 4714 is radially expanded and plastically deformed by the tapered external surface 4712a of the primary tubular expansion cone 4712 until the end of the expandable tubular casing impacts the end face of the shoulders 4724d of the float shoe 4724.

[000401] In an exemplary embodiment, during the operation of the system 4700, as illustrated in Fig. 47d, the passages 4702a, 4704a, 4706a, 4708a, 4710a, and 4718a may continue to be pressurized by the continued injection of the fluidic material 4736 into the system. As a result, the casing lock assembly 4708 and the tension actuator assembly 4710 may continue to be operated in the manner described above with reference to Fig. 47c. Furthermore, as a result, the primary tubular expansion cone 4712 is further displaced upwardly in the longitudinal direction 4738 relative to the expandable tubular casing 4714, and the secondary tubular expansion cone 4718 is displaced upwardly relative to the expandable tubular sleeve 4720, and the sealing member 4722 in the longitudinal direction 4738. Note that the further upward displacement of the expandable tubular sleeve 4720, the sealing member 4722, and the float shoe 4724, during the continued operation of the tension actuator assembly 4710, is prevented due to the interaction between the end of the expandable tubular casing 4714 and the end face of the shoulders 4724d of the float shoe 4724. Furthermore, as a result, the end of the expandable tubular casing 4714 is further radially expanded and plastically deformed by the tapered external surface 4712a of the primary tubular expansion cone 4712, and portions, 4720a and 4720b, of the expandable tubular sleeve 4720 are radially expanded and plastically deformed by the tapered external surface 4718c of the secondary tubular expansion cone 4718 within the expandable tubular casing. As a result, the sealing member 4722 engages and fluidicly seals the interface between the expandable tubular casing 4714 and the expandable tubular sleeve 4720. Furthermore, in an exemplary embodiment, as a result of the radial expansion and plastic deformation of the portions, 4720a and 4720b, of the expandable tubular sleeve 4720 within the expandable tubular casing 4714, a metal to metal, fluid tight seal is formed between the interior surface of the expandable tubular casing and the exterior surface of the expandable tubular sleeve. In an exemplary embodiment, once the portions, 4720a and 4720b, of the expandable tubular sleeve 4720 are completely radially expanded and plastically deformed by the tapered external surface 4718c of the secondary tubular expansion cone 4718, the casing lock assembly 4708 releases the expandable tubular casing 4714.

[000402] In an exemplary embodiment, during the operation of the system 4700, as illustrated in Fig. 47e, following the release of the expandable tubular casing 4714 from the casing lock assembly 4708, the

continued injection of the fluidic material 4736 into the passages of the system will further displace the primary tubular expansion cone 4712 upwardly in the longitudinal direction 4738 relative to the expandable tubular casing 4714. As a result, the expandable tubular casing 4714 is further radially expanded and plastically deformed by the tapered external surface 4712a of the primary tubular expansion cone 4712.

[000403] In several alternative embodiments, the tension actuator assembly 4710 may be operated to radially expand and plastically deform the expandable tubular sleeve 4720 by operating the tension actuator assembly in a first stroke to radially expand and plastically deform a portion of the expandable tubular sleeve 4720. After completing the first stroke of the tension actuator assembly 4710, the casing lock assembly 4708 is operated to release the expandable tubular casing 4714, such as, for example, by reducing the operating pressure of the fluidic material 4736. The tension actuator assembly 4710 is then re-set to an initial position by displacing the tubular support member 4702, the tubular safety sub 4704, the ball gripper assembly 4706, the casing lock assembly, and the portion of the tension actuator assembly rigidly coupled to the end of the casing lock assembly upwardly relative to the expandable tubular casing 4714. The operating pressure of the fluidic material 4736 is increased, and the tension actuator assembly is then operated in a second stroke to radially expand and plastically deform a further portion of the expandable tubular sleeve 4720. In several exemplary embodiments, this process may be repeated as often as required in order to radially expand and plastically deform the desired portions of the expandable tubular sleeve 4720. In an exemplary embodiment, during the first stroke, re-setting of, and/or the second stroke of the tension actuator assembly 4710, the ball gripper assembly 4706 is also operated to limit displacement of the expandable tubular casing 4714 in one or more longitudinal directions by, for example, adjusting the operating pressure of the fluidic material 4736.

[000404] In an exemplary embodiment, the maximum outside diameter of the system 4700, during the placement of the system within the wellbore 4726, is defined by the maximum outside diameter of the expandable tubular casing 4714.

[000405] In several alternative embodiments, the system 4700 includes the ball gripper assembly 4706 and/or the casing lock assembly 4708.

[000406] In several alternative embodiments, the casing lock assembly 4708 is omitted from the system 4700. As a result, the system 4700 relies only upon the ball gripper assembly 4706 to limit displacement of the expandable tubular casing 4714.

[000407] In several exemplary embodiments of the system 4700, the operation of the ball gripper assembly 4706 and/or the casing lock assembly 4708 may be replaced with, or enhanced by, the use of conventional hydraulic or mechanical slips.

[000408] In several exemplary embodiments of the system 4700, the expandable tubular sleeve 4720 is fabricated from materials particularly suited to being removed using a drilling device such as, for example, aluminum or brass.

[000409] In several exemplary embodiments of the system 4700, the float shoe 4724 may include a

sliding sleeve valve for controlling the flow of fluidic materials through the float shoe. In several exemplary embodiments of the system 4700, the secondary tubular expansion cone 4718 includes a conventional stinger attached thereto for manipulating and thereby controlling the operation of the sliding sleeve valve.

[000410] Referring to Fig. 48a, an exemplary embodiment of a system 4800 for radially expanding a tubular member includes a tubular support member 4802 that defines a passage 4802a. An end of a conventional tubular safety sub 4804 that defines a passage 4804a is coupled to an end of the tubular support member 4802, and another end of the safety sub 4804 is coupled to an end of a tubular ball gripper assembly 4806 that defines a passage 4806a.

[000411] In several exemplary embodiments, the ball gripper assembly 4806 may be a conventional device for limiting movement of tubular member relative to another member that employs, for example, one or more separate discrete ball-like elements to controllably engage and limit relative movement of the tubular member in one or more directions. In several alternative embodiments, the ball gripper assembly 4806 may include one or more elements of the ball gripper assemblies disclosed in one or more of the following: (1) PCT patent application serial number PCT/US02/36157, attorney docket number 25791.87.02, filed on 11/12/2002, (2) PCT patent application serial number PCT/US02/36267, attorney docket number 25791.88.02, filed on 11/12/2002, (3) PCT patent application serial number PCT/US03/04837, attorney docket number 25791.95.02, filed on 2/29/2003, (4) PCT patent application serial number PCT/US03/29859, attorney docket no. 25791.102.02, filed on 9/22/2003, (5) PCT patent application serial number PCT/US03/14153, attorney docket number 25791.104.02, filed on 11/13/2003, (6) PCT patent application serial number PCT/US03/18530, attorney docket number 25791.108.02, filed on 6/11/2003, (7) PCT patent application serial number PCT/US03/29858, attorney docket number 25791.112.02, (8) PCT patent application serial number PCT/US03/29460, attorney docket number 25791.114.02, filed on 9/23/2003, filed on 9/22/2003, (9) PCT patent application serial number PCT/US04/07711, attorney docket number 25791.253.02, filed on 3/11/2004, (10) PCT patent application serial number PCT/US2004/009434, attorney docket number 25791.260.02, filed on 3/26/2004, (11) PCT patent application serial number PCT/US2004/010317, attorney docket number 25791.270.02, filed on 4/2/2004, (12) PCT patent application serial number PCT/US2004/010712, attorney docket number 25791.272.02, filed on 4/7/2004, (13) PCT patent application serial number PCT/US2004/010762, attorney docket number 25791.273.02, filed on 4/6/2004, and/or (14) PCT patent application serial number PCT/US2004/011973, attorney docket number 25791.277.02, filed on April 15, 2004, the disclosures of which are incorporated herein by reference.

[000412] An end of a tubular casing lock assembly 4808 that defines a passage 4808a is coupled to the other end of the ball gripper assembly 4806. In several exemplary embodiments, the casing lock assembly 4808 may be a conventional device for limiting movement of a tubular member relative to another member. In several alternative embodiments, the casing lock assembly 4808 may include one or more elements of the casing lock assemblies disclosed in one or more of the following: (1) PCT patent

application serial number PCT/US02/36157, attorney docket number 25791.87.02, filed on 11/12/2002, (2) PCT patent application serial number PCT/US02/36267, attorney docket number 25791.88.02, filed on 11/12/2002, (3) PCT patent application serial number PCT/US03/04837, attorney docket number 25791.95.02, filed on 2/29/2003, (4) PCT patent application serial number PCT/US03/29859, attorney docket no. 25791.102.02, filed on 9/22/2003, (5) PCT patent application serial number PCT/US03/14153, attorney docket number 25791.104.02, filed on 11/13/2003, (6) PCT patent application serial number PCT/US03/18530, attorney docket number 25791.108.02, filed on 6/11/2003, (7) PCT patent application serial number PCT/US03/29858, attorney docket number 25791.112.02, (8) PCT patent application serial number PCT/US03/29460, attorney docket number 25791.114.02, filed on 9/23/2003, filed on 9/22/2003, (9) PCT patent application serial number PCT/US04/07711, attorney docket number 25791.253.02, filed on 3/11/2004, (10) PCT patent application serial number PCT/US2004/009434, attorney docket number 25791.260.02, filed on 3/26/2004, (11) PCT patent application serial number PCT/US2004/010317, attorney docket number 25791.270.02, filed on 4/2/2004, (12) PCT patent application serial number PCT/US2004/010712, attorney docket number 25791.272.02, filed on 4/7/2004, (13) PCT patent application serial number PCT/US2004/010762, attorney docket number 25791.273.02, filed on 4/6/2004, and/or (14) PCT patent application serial number PCT/US2004/011973, attorney docket number 25791.277.02, filed on April 15, 2004, the disclosures of which are incorporated herein by reference.

[000413] An end of a tubular tension actuator assembly 4810 that defines a passage 4810a is coupled to the other end of the casing lock assembly 4808. In several exemplary embodiments, the tubular tension actuator assembly 4810 may be a conventional device for displacing a member relative to another member. In several alternative embodiments, the tubular tension actuator assembly 4810 may include one or more elements of the tension actuator assemblies disclosed in one or more of the following: (1) PCT patent application serial number PCT/US02/36157, attorney docket number 25791.87.02, filed on 11/12/2002, (2) PCT patent application serial number PCT/US02/36267, attorney docket number 25791.88.02, filed on 11/12/2002, (3) PCT patent application serial number PCT/US03/04837, attorney docket number 25791.95.02, filed on 2/29/2003, (4) PCT patent application serial number PCT/US03/29859, attorney docket no. 25791.102.02, filed on 9/22/2003, (5) PCT patent application serial number PCT/US03/14153, attorney docket number 25791.104.02, filed on 11/13/2003, (6) PCT patent application serial number PCT/US03/18530, attorney docket number 25791.108.02, filed on 6/11/2003, (7) PCT patent application serial number PCT/US03/29858, attorney docket number 25791.112.02, (8) PCT patent application serial number PCT/US03/29460, attorney docket number 25791.114.02, filed on 9/23/2003, filed on 9/22/2003, (9) PCT patent application serial number PCT/US04/07711, attorney docket number 25791.253.02, filed on 3/11/2004, (10) PCT patent application serial number PCT/US2004/009434, attorney docket number 25791.260.02, filed on 3/26/2004, (11) PCT patent application serial number PCT/US2004/010317, attorney docket number 25791.270.02, filed on 4/2/2004, (12) PCT patent application serial number PCT/US2004/010712,

attorney docket number 25791.272.02, filed on 4/7/2004, (13) PCT patent application serial number PCT/US2004/010762, attorney docket number 25791.273.02, filed on 4/6/2004, and/or (14) PCT patent application serial number PCT/US2004/011973, attorney docket number 25791.277.02, filed on April 15, 2004, the disclosures of which are incorporated herein by reference.

[000414] An end of a tubular support member 4812 that defines a passage 4812a and includes an external annular recess 4812b is coupled to the other end of the tubular tension actuator assembly 4810. A sealing cup assembly 4814 is positioned within and coupled to the external annular recess 4812b of the 4812. In several exemplary embodiments, the sealing cup assembly 4814 may include one or more conventional sealing cup assemblies and/or one or more of the elements of one or more of the sealing cup assemblies disclosed in one or more of the following: (1) PCT patent application serial number PCT/US02/36157, attorney docket number 25791.87.02, filed on 11/12/2002, (2) PCT patent application serial number PCT/US02/36267, attorney docket number 25791.88.02, filed on 11/12/2002, (3) PCT patent application serial number PCT/US03/04837, attorney docket number 25791.95.02, filed on 2/29/2003, (4) PCT patent application serial number PCT/US03/29859, attorney docket no. 25791.102.02, filed on 9/22/2003, (5) PCT patent application serial number PCT/US03/14153, attorney docket number 25791.104.02, filed on 11/13/2003, (6) PCT patent application serial number PCT/US03/18530, attorney docket number 25791.108.02, filed on 6/11/2003, (7) PCT patent application serial number PCT/US03/29858, attorney docket number 25791.112.02, (8) PCT patent application serial number PCT/US03/29460, attorney docket number 25791.114.02, filed on 9/23/2003, filed on 9/22/2003, (9) PCT patent application serial number PCT/US04/07711, attorney docket number 25791.253.02, filed on 3/11/2004, (10) PCT patent application serial number PCT/US2004/009434, attorney docket number 25791.260.02, filed on 3/26/2004, (11) PCT patent application serial number PCT/US2004/010317, attorney docket number 25791.270.02, filed on 4/2/2004, (12) PCT patent application serial number PCT/US2004/010712, attorney docket number 25791.272.02, filed on 4/7/2004, (13) PCT patent application serial number PCT/US2004/010762, attorney docket number 25791.273.02, filed on 4/6/2004, and/or (14) PCT patent application serial number PCT/US2004/011973, attorney docket number 25791.277.02, filed on April 15, 2004, the disclosures of which are incorporated herein by reference.

[000415] An end of an expansion device assembly 4816 that defines a passage 4816a and a mounting hole 4816aa and includes an adjustable expansion device 4816b at one end, an external annular recess 4816c, a tapered external expansion surface 4816d, an internal annular recess 4816e, and a plurality of circumferentially spaced apart teeth 4816f at another end is coupled to the other end of the tubular support member 4812. In several exemplary embodiments, the adjustable expansion device 4816b may be a conventional adjustable expansion device that may include a tapered outer expansion surface whose shape, size, and/or position is adjustable, a rotary expansion device, one or more of the elements of the conventional commercially available expansion devices of Baker Hughes, Halliburton, Schlumberger, Weatherford, and/or Enventure Global Technology, L.L.C. and/or one or more of the elements of the

issued patents and published patent applications assigned or licensed to Baker Hughes, Halliburton, Schlumberger, Weatherford, and/or Enventure Global Technology, L.L.C. In several exemplary embodiments, the adjustable expansion device 4816b includes one or more elements of one or more of the adjustable expansion devices disclosed in one or more of the following: (1) PCT patent application serial number PCT/US02/36157, attorney docket number 25791.87.02, filed on 11/12/2002, (2) PCT patent application serial number PCT/US02/36267, attorney docket number 25791.88.02, filed on 11/12/2002, (3) PCT patent application serial number PCT/US03/04837, attorney docket number 25791.95.02, filed on 2/29/2003, (4) PCT patent application serial number PCT/US03/29859, attorney docket no. 25791.102.02, filed on 9/22/2003, (5) PCT patent application serial number PCT/US03/14153, attorney docket number 25791.104.02, filed on 11/13/2003, (6) PCT patent application serial number PCT/US03/18530, attorney docket number 25791.108.02, filed on 6/11/2003, (7) PCT patent application serial number PCT/US03/29858, attorney docket number 25791.112.02, (8) PCT patent application serial number PCT/US03/29460, attorney docket number 25791.114.02, filed on 9/23/2003, filed on 9/22/2003, (9) PCT patent application serial number PCT/US04/07711, attorney docket number 25791.253.02, filed on 3/11/2004, (10) PCT patent application serial number PCT/US2004/009434, attorney docket number 25791.260.02, filed on 3/26/2004, (11) PCT patent application serial number PCT/US2004/010317, attorney docket number 25791.270.02, filed on 4/2/2004, (12) PCT patent application serial number PCT/US2004/010712, attorney docket number 25791.272.02, filed on 4/7/2004, (13) PCT patent application serial number PCT/US2004/010762, attorney docket number 25791.273.02, filed on 4/6/2004, and/or (14) PCT patent application serial number PCT/US2004/011973, attorney docket number 25791.277.02, filed on April 15, 2004, the disclosures of which are incorporated herein by reference.

[000416] An end of a mounting pin 4818 is received within and coupled to the mounting hole 4816aa of the expansion device assembly 4816, and another of the mounting pin is received within a mounting hole 4820a defined within an expandable tubular casing 4820 that receives the tubular support member 4802, the tubular safety sub 4804, the tubular ball gripper assembly 4806, the tubular casing lock assembly 4808, the tubular tension actuator assembly 4810, the tubular support member 4812, the sealing cup assembly 4814, and the end of the expansion device assembly 4816.

[000417] In an exemplary embodiment, the expandable tubular casing 4820 is provided and includes one or more of the properties of the expandable tubulars described above with reference to Figs. 1 to 46j. In an exemplary embodiment, during the operation of the system 4800, the mounting pin 4818 permits torque to be transmitted between the expandable tubular casing 4820 and the expansion device assembly 4816. In an exemplary embodiment, the torque pin 4818 is fabricated from a drillable material such as, for example, brass or aluminum. In an exemplary embodiment, the sealing cup assembly 4814 sealingly engages the internal diameter of the expandable tubular casing 4820 during the operation of the system 4800.

[000418] An expandable tubular sleeve 4822 that includes a first end 4822a including an external

annular recess 4822aa, an intermediate portion 4822b, and a second end 4822c having an internal threaded connection 4822d mates with and is received within the external annular recess 4816c of the expansion device assembly 4816. In an exemplary embodiment, the wall thickness of the first end 4822a of the expandable tubular sleeve 4822 is greater than the wall thickness of the second end 4822c of the expandable tubular sleeve, and the wall thickness of the intermediate portion 4822b of the expandable tubular sleeve is tapered. In an exemplary embodiment, the intermediate portion 4822b of the expandable tubular sleeve 4822 mates with and receives the external tapered surface 4816d of the expansion device assembly 4816. In an exemplary embodiment, the expandable tubular sleeve 4822 is provided and includes one or more of the properties of the expandable tubulars described above with reference to Figs. 1 to 46j.

[000419] A sealing member 4824 is received within and coupled to the external annular recess 4822aa of the first end 4822a of the expandable tubular sleeve 4822. In an exemplary embodiment, the outside diameter of the intermediate portion 4822b and the second end 4822c of the tubular sleeve 4822 are both less than or equal to the maximum outside diameter of the expandable tubular casing 4822. In an exemplary embodiment, the outside diameter of the sealing member 4824 is less than or equal to the maximum outside diameter of the expandable tubular casing 4820.

[000420] A float shoe 4826 that defines a passage 4826a having a throat 4826aa and a passage 4826b and includes an external annular recess 4826c at one end that is received within and mates with the internal annular recess 4816e of the end of the expansion device assembly 4816, a plurality of circumferentially spaced apart shoulders 4826d at another end, a plurality of circumferentially spaced apart teeth 4826e for engaging the circumferentially spaced apart teeth 4816f of the end of the expansion device assembly 4816, and a conventional float element 4826f is received within, mates with, and is coupled to the internal threaded connection 4822d of the end of the expandable tubular sleeve 4822. In an exemplary embodiment, the outside diameter of the spaced apart shoulders 4826d of the float shoe 4826 are greater than the outside diameters of both the expandable tubular casing 4820 and the expandable tubular sleeve 4822. In an exemplary embodiment, during the operation of the system 4800, the interaction of the circumferentially spaced apart teeth 4826e of the float shoe 4826 with the circumferentially spaced apart teeth 4816f of the expansion device assembly 4816 permits torque loads to be transmitted there between. In an exemplary embodiment, during the operation of the system 4800, the circumferentially spaced apart shoulders 4826d further define circumferentially spaced apart axial flow passages there between.

[000421] In an exemplary embodiment, during operation of the system 4800, as illustrated in Fig. 48a, the system is positioned within a wellbore 4828 that traverses a subterranean formation 4830. A hardenable fluidic sealing material 4832 such as, for example, cement may then be injected into the system 4800 through the passages 4802a, 4804a, 4806a, 4808a, 4810a, 4812a, 4816a, and 4826a. The fluidic material 4832 may then be conveyed past the float element 4826f of the float shoe 4826 and through the passage 4826b into an annulus 4834 between the system 4800 and the interior surface of the

wellbore 4828. The fluidic material 4832 within the annulus 4834 may then be allowed to at least partially cure.

[000422] In an exemplary embodiment, during the operation of the system 4800, as illustrated in Fig. 48b, a conventional plug 4836 is then positioned within the throat 4826aa of the passage 4826a of the float shoe 4826 by injecting fluidic material 4838 into the system 4800 through the passages 4802a, 4804a, 4806a, 4808a, 4810a, 4812a, and 4816a. As a result, the passage 4826a of the float shoe 4826 is blocked and the passages 4802a, 4804a, 4806a, 4808a, 4810a, 4812a, and 4816a may be pressurized by the continued injection of the fluidic material 4838.

[000423] In an exemplary embodiment, during the operation of the system 4800, as illustrated in Fig. 48c, the passages 4802a, 4804a, 4806a, 4808a, 4810a, 4812a and 4816a may be pressurized by the continued injection of the fluidic material 4838 into the system. As a result, the casing lock assembly 4808 is operated to engage the expandable tubular casing 4820 and the outside diameter of the adjustable expansion device 4816b of the expansion device assembly 4816 is increased. In an exemplary embodiment, the adjustable expansion device 4816b of the expansion device assembly 4816 includes one or more external expansion surfaces 4816ba for engaging and radially expanding and plastically deforming the expandable tubular casing 4820.

[000424] In an exemplary embodiment, during the operation of the system 4800, as illustrated in Fig. 48d, the passages 4802a, 4804a, 4806a, 4808a, 4810a, 4812a and 4816a may continue to be pressurized by the continued injection of the fluidic material 4838 into the system. As a result, the casing lock assembly 4808 continues to be operated to engage the expandable tubular casing 4820 and the tension actuator assembly 4810 is operated to displace the expansion device assembly 4816, expandable tubular sleeve 4822, sealing member 4824, and float shoe 4826 upwardly in a longitudinal direction 4840 relative to the expandable tubular casing 4820. As a result, the end of the expandable tubular casing 4820 is radially expanded and plastically deformed by the external expansion surfaces 4816ba of the adjustable expansion device 4816b of the expansion device assembly 4816. Furthermore, as a result, the radially expanded and plastically deformed end of the tubular casing 4820 receives and mates with the expandable tubular sleeve 4822 and the sealing member 4824. Furthermore, as a result, the mounting pin 4818 is sheared. In an exemplary embodiment, the end of the expandable tubular casing 4820 is radially expanded and plastically deformed by the external expansion surfaces 4816ba of the adjustable expansion device 4816b of the expansion device assembly 4816 until the end of the expandable tubular casing impacts the end face of the shoulders 4826d of the float shoe 4826.

[000425] In an exemplary embodiment, during the operation of the system 4800, as illustrated in Fig. 48e, the passages 4802a, 4804a, 4806a, 4808a, 4810a, 4812a, and 4816a may continue to be pressurized by the continued injection of the fluidic material 4838 into the system. As a result, the casing lock assembly 4808 and the tension actuator assembly 4810 may continue to be operated in the manner described above with reference to Fig. 48d. Furthermore, as a result, the adjustable expansion device 4816b of the expansion device assembly 4816 is further displaced upwardly in the longitudinal direction

4840 relative to the expandable tubular casing 4820, and the tapered external expansion surface 4816d of the expansion device assembly is displaced upwardly relative to the expandable tubular sleeve 4822, and the sealing member 4824 in the longitudinal direction 4838. Note that the further upward displacement of the expandable tubular sleeve 4822, the sealing member 4824, and the float shoe 4826, during the continued operation of the tension actuator assembly 4810, is prevented due to the interaction between the end of the expandable tubular casing 4820 and the end face of the shoulders 4826d of the float shoe 4826. Furthermore, as a result, the end of the expandable tubular casing 4820 is further radially expanded and plastically deformed by the external expansion surfaces 4816ba of the adjustable expansion device 4816b of the expansion device assembly 4816, and portions, 4822a and 4822b, of the expandable tubular sleeve 4822 are radially expanded and plastically deformed by the tapered external expansion surface 4816d of the expansion device assembly within the end of the expandable tubular casing. As a result, the sealing member 4824 engages and fluidicly seals the interface between the expandable tubular casing 4820 and the expandable tubular sleeve 4822. Furthermore, in an exemplary embodiment, as a result of the radial expansion and plastic deformation of the portions, 4822a and 4822b, of the expandable tubular sleeve 4822 within the end of the expandable tubular casing 4820, a metal to metal, fluid tight seal is formed between the interior surface of the expandable tubular casing and the exterior surface of the expandable tubular sleeve. In an exemplary embodiment, once the portions, 4822a and 4822b, of the expandable tubular sleeve 4822 are completely radially expanded and plastically deformed by the tapered external expansion surface 4816d of the expansion device assembly 4816, the casing lock assembly 4808 releases the expandable tubular casing 4820.

[000426] In an exemplary embodiment, during the operation of the system 4800, as illustrated in Fig. 48f, following the release of the expandable tubular casing 4820 from the casing lock assembly 4808, the continued injection of the fluidic material 4838 into the passages of the system will further displace the adjustable expansion device 4816b of the expansion device assembly 4816 upwardly in the longitudinal direction 4840 relative to the expandable tubular casing 4820. In an exemplary embodiment, during the displacement of the adjustable expansion device 4816b of the expansion device assembly 4816 upwardly in the longitudinal direction 4840 relative to the expandable tubular casing 4820, the sealing cup assembly 4814 sealingly engages the internal surface of the expandable tubular casing 4820. As a result, the annulus within the expandable tubular casing 4820 below and proximate to the sealing cup assembly 4814 is pressurized by the injection of the fluidic material 4838 into the system 4800 thereby applying an upward axial force to the tubular support member 4812. As a result, the adjustable expansion device 4816b of the expansion device assembly 4816 is pulled through the expandable tubular casing 4820. As a result, the expandable tubular casing 4820 is further radially expanded and plastically deformed by the external expansion surfaces 4816ba of the adjustable expansion device 4816b of the expansion device assembly 4816.

[000427] In several alternative embodiments, the tension actuator assembly 4810 may be operated to radially expand and plastically deform the expandable tubular sleeve 4822 by operating the tension

actuator assembly in a first stroke to radially expand and plastically deform a portion of the expandable tubular sleeve 4822. After completing the first stroke of the tension actuator assembly 4810, the casing lock assembly 4808 is operated to release the expandable tubular casing 4820, such as, for example, by reducing the operating pressure of the fluidic material 4838. The tension actuator assembly 4810 is then re-set to an initial position by displacing the tubular support member 4802, the tubular safety sub 4804, the ball gripper assembly 4806, the casing lock assembly 4808, and the portion of the tension actuator assembly rigidly coupled to the end of the casing lock assembly upwardly relative to the expandable tubular casing 4820. The operating pressure of the fluidic material 4838 is increased, and the tension actuator assembly 4810 is then operated in a second stroke to radially expand and plastically deform a further portion of the expandable tubular sleeve 4822. In several exemplary embodiments, this process may be repeated as often as required in order to radially expand and plastically deform the desired portions of the expandable tubular sleeve 4822. In an exemplary embodiment, during the first stroke, re-setting of, and/or the second stroke of the tension actuator assembly 4810, the ball gripper assembly 4806 is also operated to limit displacement of the expandable tubular casing 4820 in one or more longitudinal directions by, for example, adjusting the operating pressure of the fluidic material 4838.

[000428] In an exemplary embodiment, the maximum outside diameter of the system 4800, during the placement of the system within the wellbore 4828, is defined by the maximum outside diameter of the expandable tubular casing 4820.

[000429] In several alternative embodiments, the system 4800 includes the ball gripper assembly 4806 and/or the casing lock assembly 4808.

[000430] In several alternative embodiments, the casing lock assembly 4808 is omitted from the system 4800. As a result, the system 4800 relies only upon the ball gripper assembly 4806 to limit displacement of the expandable tubular casing 4820.

[000431] In several exemplary embodiments of the system 4800, the operation of the ball gripper assembly 4806 and/or the casing lock assembly 4808 may be replaced with, or enhanced by, the use of conventional hydraulic or mechanical slips.

[000432] In several exemplary embodiments of the system 4800, the expandable tubular sleeve 4822 is fabricated from materials particularly suited to being removed using a drilling device such as, for example, aluminum or brass.

[000433] In several exemplary embodiments of the system 4800, the float shoe 4826 may include a sliding sleeve valve for controlling the flow of fluidic materials through the float shoe. In several exemplary embodiments of the system 4800, the end of the expansion device assembly 4816 includes a conventional stinger attached thereto for manipulating and thereby controlling the operation of the sliding sleeve valve.

[000434] In several exemplary embodiments, the sealing cup assembly 4814 may be positioned above or below the casing lock assembly 4808.

[000435] Referring to Fig. 49a, an exemplary embodiment of a system 4900 for radially expanding a

tubular member includes a tubular support member 4902 that defines a passage 4902a. An end of a conventional tubular safety sub 4904 that defines a passage 4904a is coupled to an end of the tubular support member 4902, and another end of the safety sub 4904 is coupled to an end of a tubular ball gripper assembly 4906 that defines a passage 4906a.

[000436] In several exemplary embodiments, the ball gripper assembly 4906 may be a conventional device for limiting movement of tubular member relative to another member that employs, for example, one or more separate discrete ball-like elements to controllably engage and limit relative movement of the tubular member in one or more directions. In several alternative embodiments, the ball gripper assembly 4906 may include one or more elements of the ball gripper assemblies disclosed in one or more of the following: (1) PCT patent application serial number PCT/US02/36157, attorney docket number 25791.87.02, filed on 11/12/2002, (2) PCT patent application serial number PCT/US02/36267, attorney docket number 25791.88.02, filed on 11/12/2002, (3) PCT patent application serial number PCT/US03/04837, attorney docket number 25791.95.02, filed on 2/29/2003, (4) PCT patent application serial number PCT/US03/29859, attorney docket no. 25791.102.02, filed on 9/22/2003, (5) PCT patent application serial number PCT/US03/14153, attorney docket number 25791.104.02, filed on 11/13/2003, (6) PCT patent application serial number PCT/US03/18530, attorney docket number 25791.108.02, filed on 6/11/2003, (7) PCT patent application serial number PCT/US03/29858, attorney docket number 25791.112.02, (8) PCT patent application serial number PCT/US03/29460, attorney docket number 25791.114.02, filed on 9/23/2003, filed on 9/22/2003, (9) PCT patent application serial number PCT/US04/07711, attorney docket number 25791.253.02, filed on 3/11/2004, (10) PCT patent application serial number PCT/US2004/009434, attorney docket number 25791.260.02, filed on 3/26/2004, (11) PCT patent application serial number PCT/US2004/010317, attorney docket number 25791.270.02, filed on 4/2/2004, (12) PCT patent application serial number PCT/US2004/010712, attorney docket number 25791.272.02, filed on 4/7/2004, (13) PCT patent application serial number PCT/US2004/010762, attorney docket number 25791.273.02, filed on 4/6/2004, and/or (14) PCT patent application serial number PCT/US2004/011973, attorney docket number 25791.277.02, filed on April 15, 2004, the disclosures of which are incorporated herein by reference.

[000437] An end of a tubular casing lock assembly 4908 that defines a passage 4908a is coupled to the other end of the ball gripper assembly 4908. In several exemplary embodiments, the casing lock assembly 4908 may be a conventional device for limiting movement of a tubular member relative to another member. In several alternative embodiments, the casing lock assembly 4908 may include one or more elements of the casing lock assemblies disclosed in one or more of the following: (1) PCT patent application serial number PCT/US02/36157, attorney docket number 25791.87.02, filed on 11/12/2002, (2) PCT patent application serial number PCT/US02/36267, attorney docket number 25791.88.02, filed on 11/12/2002, (3) PCT patent application serial number PCT/US03/04837, attorney docket number 25791.95.02, filed on 2/29/2003, (4) PCT patent application serial number PCT/US03/29859, attorney docket no. 25791.102.02, filed on 9/22/2003, (5) PCT patent application serial number PCT/US03/14153,

attorney docket number 25791.104.02, filed on 11/13/2003, (6) PCT patent application serial number PCT/US03/18530, attorney docket number 25791.108.02, filed on 6/11/2003, (7) PCT patent application serial number PCT/US03/29858, attorney docket number 25791.112.02, (8) PCT patent application serial number PCT/US03/29460, attorney docket number 25791.114.02, filed on 9/23/2003, filed on 9/22/2003, (9) PCT patent application serial number PCT/US04/07711, attorney docket number 25791.253.02, filed on 3/11/2004, (10) PCT patent application serial number PCT/US2004/009434, attorney docket number 25791.260.02, filed on 3/26/2004, (11) PCT patent application serial number PCT/US2004/010317, attorney docket number 25791.270.02, filed on 4/2/2004, (12) PCT patent application serial number PCT/US2004/010712, attorney docket number 25791.272.02, filed on 4/7/2004, (13) PCT patent application serial number PCT/US2004/010762, attorney docket number 25791.273.02, filed on 4/6/2004, and/or (14) PCT patent application serial number PCT/US2004/011973, attorney docket number 25791.277.02, filed on April 15, 2004, the disclosures of which are incorporated herein by reference.

[000438] An end of a tubular tension actuator assembly 4910 that defines a passage 4910a is coupled to the other end of the casing lock assembly 4908. In several exemplary embodiments, the tubular tension actuator assembly 4910 may be a conventional device for displacing a member relative to another member. In several alternative embodiments, the tubular tension actuator assembly 4910 may include one or more elements of the tension actuator assemblies disclosed in one or more of the following: (1) PCT patent application serial number PCT/US02/36157, attorney docket number 25791.87.02, filed on 11/12/2002, (2) PCT patent application serial number PCT/US02/36267, attorney docket number 25791.88.02, filed on 11/12/2002, (3) PCT patent application serial number PCT/US03/04837, attorney docket number 25791.95.02, filed on 2/29/2003, (4) PCT patent application serial number PCT/US03/29859, attorney docket no. 25791.102.02, filed on 9/22/2003, (5) PCT patent application serial number PCT/US03/14153, attorney docket number 25791.104.02, filed on 11/13/2003, (6) PCT patent application serial number PCT/US03/18530, attorney docket number 25791.108.02, filed on 6/11/2003, (7) PCT patent application serial number PCT/US03/29858, attorney docket number 25791.112.02, (8) PCT patent application serial number PCT/US03/29460, attorney docket number 25791.114.02, filed on 9/23/2003, filed on 9/22/2003, (9) PCT patent application serial number PCT/US04/07711, attorney docket number 25791.253.02, filed on 3/11/2004, (10) PCT patent application serial number PCT/US2004/009434, attorney docket number 25791.260.02, filed on 3/26/2004, (11) PCT patent application serial number PCT/US2004/010317, attorney docket number 25791.270.02, filed on 4/2/2004, (12) PCT patent application serial number PCT/US2004/010712, attorney docket number 25791.272.02, filed on 4/7/2004, (13) PCT patent application serial number PCT/US2004/010762, attorney docket number 25791.273.02, filed on 4/6/2004, and/or (14) PCT patent application serial number PCT/US2004/011973, attorney docket number 25791.277.02, filed on April 15, 2004, the disclosures of which are incorporated herein by reference.

[000439] An end of a tubular support member 4912 that defines a passage 4912a and includes an

external annular recess 4912b is coupled to the other end of the tubular tension actuator assembly 4910. A sealing cup assembly 4914 is positioned within and coupled to the external annular recess 4912b of the tubular support member 4912. In several exemplary embodiments, the sealing cup assembly 4914 may include one or more conventional sealing cup assemblies and/or one or more of the elements of one or more of the sealing cup assemblies disclosed in one or more of the following: (1) PCT patent application serial number PCT/US02/36157, attorney docket number 25791.87.02, filed on 11/12/2002, (2) PCT patent application serial number PCT/US02/36267, attorney docket number 25791.88.02, filed on 11/12/2002, (3) PCT patent application serial number PCT/US03/04837, attorney docket number 25791.95.02, filed on 2/29/2003, (4) PCT patent application serial number PCT/US03/29859, attorney docket no. 25791.102.02, filed on 9/22/2003, (5) PCT patent application serial number PCT/US03/14153, attorney docket number 25791.104.02, filed on 11/13/2003, (6) PCT patent application serial number PCT/US03/18530, attorney docket number 25791.108.02, filed on 6/11/2003, (7) PCT patent application serial number PCT/US03/29858, attorney docket number 25791.112.02, (8) PCT patent application serial number PCT/US03/29460, attorney docket number 25791.114.02, filed on 9/23/2003, filed on 9/22/2003, (9) PCT patent application serial number PCT/US04/07711, attorney docket number 25791.253.02, filed on 3/11/2004, (10) PCT patent application serial number PCT/US2004/009434, attorney docket number 25791.260.02, filed on 3/26/2004, (11) PCT patent application serial number PCT/US2004/010317, attorney docket number 25791.270.02, filed on 4/2/2004, (12) PCT patent application serial number PCT/US2004/010712, attorney docket number 25791.272.02, filed on 4/7/2004, (13) PCT patent application serial number PCT/US2004/010762, attorney docket number 25791.273.02, filed on 4/6/2004, and/or (14) PCT patent application serial number PCT/US2004/011973, attorney docket number 25791.277.02, filed on April 15, 2004, the disclosures of which are incorporated herein by reference.

[000440] An end of an expansion device assembly 4916 that defines a passage 4916a and a mounting hole 4916aa and includes an adjustable expansion device 4916b at one end, an external annular recess 4916c, a tapered external expansion surface 4916d, an internal annular recess 4916e, and a plurality of circumferentially spaced apart teeth 4916f at another end is coupled to the other end of the tubular support member 4912. In several exemplary embodiments, the adjustable expansion device 4916b may be a conventional adjustable expansion device that may include a tapered outer expansion surface whose shape, size, and/or position is adjustable, a rotary expansion device, one or more of the elements of the conventional commercially available expansion devices of Baker Hughes, Halliburton, Schlumberger, Weatherford, and/or Enventure Global Technology, L.L.C. and/or one or more of the elements of the issued patents and published patent applications assigned or licensed to Baker Hughes, Halliburton, Schlumberger, Weatherford, and/or Enventure Global Technology, L.L.C. In several exemplary embodiments, the adjustable expansion device 4916b includes one or more elements of one or more of the adjustable expansion devices disclosed in one or more of the following: (1) PCT patent application serial number PCT/US02/36157, attorney docket number 25791.87.02, filed on 11/12/2002, (2) PCT

patent application serial number PCT/US02/36267, attorney docket number 25791.88.02, filed on 11/12/2002, (3) PCT patent application serial number PCT/US03/04837, attorney docket number 25791.95.02, filed on 2/29/2003, (4) PCT patent application serial number PCT/US03/29859, attorney docket no. 25791.102.02, filed on 9/22/2003, (5) PCT patent application serial number PCT/US03/14153, attorney docket number 25791.104.02, filed on 11/13/2003, (6) PCT patent application serial number PCT/US03/18530, attorney docket number 25791.108.02, filed on 6/11/2003, (7) PCT patent application serial number PCT/US03/29858, attorney docket number 25791.112.02, (8) PCT patent application serial number PCT/US03/29460, attorney docket number 25791.114.02, filed on 9/23/2003, filed on 9/22/2003, (9) PCT patent application serial number PCT/US04/07711, attorney docket number 25791.253.02, filed on 3/11/2004, (10) PCT patent application serial number PCT/US2004/009434, attorney docket number 25791.260.02, filed on 3/26/2004, (11) PCT patent application serial number PCT/US2004/010317, attorney docket number 25791.270.02, filed on 4/2/2004, (12) PCT patent application serial number PCT/US2004/010712, attorney docket number 25791.272.02, filed on 4/7/2004, (13) PCT patent application serial number PCT/US2004/010762, attorney docket number 25791.273.02, filed on 4/6/2004, and/or (14) PCT patent application serial number PCT/US2004/011973, attorney docket number 25791.277.02, filed on April 15, 2004, the disclosures of which are incorporated herein by reference.

[000441] An end of a mounting pin 4918 is received within and coupled to the mounting hole 4916aa of the expansion device assembly 4916, and another of the mounting pin is received within a mounting hole 4920a defined within an expandable tubular casing 4920 that receives the tubular support member 4902, the tubular safety sub 4904, the tubular ball gripper assembly 4906, the tubular casing lock assembly 4908, the tubular tension actuator assembly 4910, the tubular support member 4912, the sealing cup assembly 4914, and the end of the expansion device assembly 4916.

[000442] In an exemplary embodiment, the expandable tubular casing 4920 is provided and includes one or more of the properties of the expandable tubulars described above with reference to Figs. 1 to 46j. In an exemplary embodiment, during the operation of the system 4900, the mounting pin 4918 permits torque to be transmitted between the expandable tubular casing 4920 and the expansion device assembly 4816. In an exemplary embodiment, the torque pin 4918 is fabricated from a drillable material such as, for example, brass or aluminum. In an exemplary embodiment, the sealing cup assembly 4914 sealingly engages the internal diameter of the expandable tubular casing 4920 during the operation of the system 4900.

[000443] An end of a tubular slotted sleeve 4921 that receives the end of the expansion device assembly 4916, including the adjustable expansion device 4916b, is coupled to an end of the expandable tubular casing 4920 and the other end of the tubular slotted sleeve includes a tapered end face 4921a. In several exemplary embodiments, the tubular slotted sleeve 4921 includes one or more perforations that may, for example, includes slots, circular holes, or other perforations.

[000444] An expandable tubular sleeve 4922 that includes a first end 4922a including a tapered

external annular recess 4922aa that mates with the tapered end face 4921a of the tubular slotted sleeve 4921, an external annular recess 4922ab spaced apart from the tapered external annular recess, an intermediate portion 4922b, and a second end 4922c having an internal threaded connection 4922d mates with and is received within the external annular recess 4916c of the expansion device assembly 4916. In an exemplary embodiment, the wall thickness of the first end 4922a of the expandable tubular sleeve 4922 is greater than the wall thickness of the second end 4922c of the expandable tubular sleeve, and the wall thickness of the intermediate portion 4922b of the expandable tubular sleeve is tapered. In an exemplary embodiment, the intermediate portion 4922b of the expandable tubular sleeve 4922 mates with and receives the external tapered surface 4916d of the expansion device assembly 4916. In an exemplary embodiment, the expandable tubular sleeve 4922 is provided and includes one or more of the properties of the expandable tubulars described above with reference to Figs. 1 to 46j.

[000445] A sealing member 4924 is received within and coupled to the external annular recess 4922ab of the first end 4922a of the expandable tubular sleeve 4922. In an exemplary embodiment, the outside diameters of the intermediate portion 4922b and the second end 4922c of the tubular sleeve 4922 are both less than or equal to the maximum outside diameter of the expandable tubular casing 4920. In an exemplary embodiment, the outside diameter of the sealing member 4924 is less than or equal to the maximum outside diameter of the expandable tubular casing 4920.

[000446] A float shoe 4926 that defines a passage 4926a having a throat 4926aa and a passage 4926b and includes an external annular recess 4926c at one end that is received within and mates with the internal annular recess 4916e of the end of the expansion device assembly 4916, a plurality of circumferentially spaced apart shoulders 4926d at another end, a plurality of circumferentially spaced apart teeth 4926e for engaging the circumferentially spaced apart teeth 4916f of the end of the expansion device assembly 4916, and a conventional float element 4926f is received within, mates with, and is coupled to the internal threaded connection 4922d of the end of the expandable tubular sleeve 4922. In an exemplary embodiment, the outside diameter of the spaced apart shoulders 4926d of the float shoe 4926 are greater than the outside diameters of both the expandable tubular casing 4920 and the expandable tubular sleeve 4922. In an exemplary embodiment, during the operation of the system 4900, the interaction of the circumferentially spaced apart teeth 4926e of the float shoe 4926 with the circumferentially spaced apart teeth 4916f of the expansion device assembly 4916 permits torque loads to be transmitted there between. In an exemplary embodiment, during the operation of the system 4900, the circumferentially spaced apart shoulders 4926d further define circumferentially spaced apart axial flow passages there between.

[000447] In an exemplary embodiment, during operation of the system 4900, as illustrated in Fig. 49a, the system is positioned within a wellbore 4928 that traverses a subterranean formation 4930. In an exemplary embodiment, during operation of the system 4900, the tubular slotted sleeve 4921 prevents debris within the wellbore 4928 from damaging the adjustable expansion device 4916b of the expansion device assembly 4916. A hardenable fluidic sealing material 4932 such as, for example, cement may

then be injected into the system 4900 through the passages 4902a, 4904a, 4906a, 4908a, 4910a, 4912a, 4916a, and 4926a. The fluidic material 4932 may then be conveyed past the float element 4926f of the float shoe 4926 and through the passage 4926b into an annulus 4934 between the system 4900 and the interior surface of the wellbore 4928. The fluidic material 4932 within the annulus 4934 may then be allowed to at least partially cure.

[000448] In an exemplary embodiment, during the operation of the system 4900, as illustrated in Fig. 49b, a conventional plug 4936 is then positioned within the throat 4926aa of the passage 4926a of the float shoe 4926 by injecting fluidic material 4938 into the system 4900 through the passages 4902a, 4904a, 4906a, 4908a, 4910a, 4912a, and 4916a. As a result, the passage 4926a of the float shoe 4926 is blocked and the passages 4902a, 4904a, 4906a, 4908a, 4910a, 4912a, and 4916a may be pressurized by the continued injection of the fluidic material 4938.

[000449] In an exemplary embodiment, during the operation of the system 4900, as illustrated in Fig. 49c, the passages 4902a, 4904a, 4906a, 4908a, 4910a, 4912a and 4916a may be pressurized by the continued injection of the fluidic material 4938 into the system. As a result, the casing lock assembly 4908 is operated to engage the expandable tubular casing 4920 and the outside diameter of the adjustable expansion device 4916b of the expansion device assembly 4916 is increased. As a result, the portion of the tubular slotted sleeve 4921 that receives the adjustable expansion device 4916b is radially expanded and plastically deformed. In an exemplary embodiment, the adjustable expansion device 4916b of the expansion device assembly 4916 includes one or more external expansion surfaces 4916ba for engaging and radially expanding and plastically deforming the tubular slotted sleeve 4921 and the expandable tubular casing 4920.

[000450] In an exemplary embodiment, during the operation of the system 4900, as illustrated in Fig. 49d, the passages 4902a, 4904a, 4906a, 4908a, 4910a, 4912a and 4916a may continue to be pressurized by the continued injection of the fluidic material 4938 into the system. As a result, the casing lock assembly 4908 continues to be operated to engage the expandable tubular casing 4920 and the tension actuator assembly 4910 is operated to displace the expansion device assembly 4916, expandable tubular sleeve 4922, sealing member 4924, and float shoe 4926 upwardly in a longitudinal direction 4940 relative to the expandable tubular casing 4920 and the tubular slotted sleeve 4921. As a result, the tubular slotted sleeve 4921 and the end of the expandable tubular casing 4920 are radially expanded and plastically deformed by the external expansion surfaces 4816ba of the adjustable expansion device 4816b of the expansion device assembly 4816. Furthermore, as a result, the tubular slotted sleeve 4921 engages the tapered end face of the shoulders 4926d of the float shoe 4926 and is thereby further radially expanded and plastically deformed. Furthermore, as a result, the radially expanded and plastically deformed end of the tubular casing 4920 receives and mates with the expandable tubular sleeve 4922 and the sealing member 4924. Furthermore, as a result, the mounting pin 4918 is sheared. In an exemplary embodiment, the end of the expandable tubular casing 4920 is radially expanded and plastically deformed by the external expansion surfaces 4916ba of the adjustable expansion device 4916b of the expansion

device assembly 4916 until the end of the expandable tubular casing impacts the end faces of the shoulders 4926d of the float shoe 4926.

[000451] In an exemplary embodiment, during the operation of the system 4900, as illustrated in Fig. 49e, the passages 4902a, 4904a, 4906a, 4908a, 4910a, 4912a, and 4916a may continue to be pressurized by the continued injection of the fluidic material 4938 into the system. As a result, the casing lock assembly 4908 and the tension actuator assembly 4910 may continue to be operated in the manner described above with reference to Fig. 49d. Furthermore, as a result, the adjustable expansion device 4916b of the expansion device assembly 4916 is further displaced upwardly in the longitudinal direction 4940 relative to the expandable tubular casing 4920, and the tapered external expansion surface 4916d of the expansion device assembly is displaced upwardly relative to the expandable tubular sleeve 4922, and the sealing member 4924 in the longitudinal direction 4938. Note that the further upward displacement of the expandable tubular sleeve 4922, the sealing member 4924, and the float shoe 4926, during the continued operation of the tension actuator assembly 4910, is prevented due to the interaction between the end of the expandable tubular casing 4920 and the end faces of the shoulders 4926d of the float shoe 4926. Furthermore, as a result, the end of the expandable tubular casing 4920 is further radially expanded and plastically deformed by the external expansion surfaces 4916ba of the adjustable expansion device 4916b of the expansion device assembly 4916, and portions, 4922a and 4922b, of the expandable tubular sleeve 4922 are radially expanded and plastically deformed by the tapered external expansion surface 4916d of the expansion device assembly within the end of the expandable tubular casing. As a result, the sealing member 4924 engages and fluidicly seals the interface between the expandable tubular casing 4920 and the expandable tubular sleeve 4922. Furthermore, in an exemplary embodiment, as a result of the radial expansion and plastic deformation of the portions, 4922a and 4922b, of the expandable tubular sleeve 4922 within the end of the expandable tubular casing 4920, a metal to metal, fluid tight seal is formed between the interior surface of the expandable tubular casing and the exterior surface of the expandable tubular sleeve. In an exemplary embodiment, once the portions, 4922a and 4922b, of the expandable tubular sleeve 4922 are completely radially expanded and plastically deformed by the tapered external expansion surface 4916d of the expansion device assembly 4916, the casing lock assembly 4908 releases the expandable tubular casing 4920.

[000452] In an exemplary embodiment, during the operation of the system 4900, as illustrated in Fig. 49f, following the release of the expandable tubular casing 4920 from the casing lock assembly 4908, the continued injection of the fluidic material 4938 into the passages of the system will further displace the adjustable expansion device 4916b of the expansion device assembly 4916 upwardly in the longitudinal direction 4940 relative to the expandable tubular casing 4920. In an exemplary embodiment, during the displacement of the adjustable expansion device 4916b of the expansion device assembly 4916 upwardly in the longitudinal direction 4940 relative to the expandable tubular casing 4920, the sealing cup assembly 4914 sealingly engage the internal surface of the expandable tubular casing 4920. As a result, the annulus within the expandable tubular casing 4920 below and proximate to the sealing cup assembly

4914 is pressurized by the injection of the fluidic material 4938 into the system 4900 thereby applying an upward axial force to the tubular support member 4912. As a result, the adjustable expansion device 4916b of the expansion device assembly 4916 is pulled through the expandable tubular casing 4920. As a result, the expandable tubular casing 4920 is further radially expanded and plastically deformed by the external expansion surfaces 4916ba of the adjustable expansion device 4916b of the expansion device assembly 4916.

[000453] In several alternative embodiments, the tension actuator assembly 4910 may be operated to radially expand and plastically deform the expandable tubular sleeve 4922 by operating the tension actuator assembly in a first stroke to radially expand and plastically deform a portion of the expandable tubular sleeve 4922. After completing the first stroke of the tension actuator assembly 4910, the casing lock assembly 4908 is operated to release the expandable tubular casing 4920, such as, for example, by reducing the operating pressure of the fluidic material 4938. The tension actuator assembly 4910 is then re-set to an initial position by displacing the tubular support member 4902, the tubular safety sub 4904, the ball gripper assembly 4906, the casing lock assembly 4908, and the portion of the tension actuator assembly rigidly coupled to the end of the casing lock assembly upwardly relative to the expandable tubular casing 4920. The operating pressure of the fluidic material 4938 is increased, and the tension actuator assembly 4910 is then operated in a second stroke to radially expand and plastically deform a further portion of the expandable tubular sleeve 4922. In several exemplary embodiments, this process may be repeated as often as required in order to radially expand and plastically deform the desired portions of the expandable tubular sleeve 4922. In an exemplary embodiment, during the first stroke, re-setting of, and/or the second stroke of the tension actuator assembly 4910, the ball gripper assembly 4906 is also operated to limit displacement of the expandable tubular casing 4920 in one or more longitudinal directions by, for example, adjusting the operating pressure of the fluidic material 4938.

[000454] In an exemplary embodiment, the maximum outside diameter of the system 4900, during the placement of the system within the wellbore 4928, is defined by the maximum outside diameter of the expandable tubular casing 4920.

[000455] In several alternative embodiments, the system 4900 includes the ball gripper assembly 4906 and/or the casing lock assembly 4908.

[000456] In several alternative embodiments, the casing lock assembly 4908 is omitted from the system 4900. As a result, the system 4900 relies only upon the ball gripper assembly 4906 to limit displacement of the expandable tubular casing 4920.

[000457] In several exemplary embodiments of the system 4900, the operation of the ball gripper assembly 4906 and/or the casing lock assembly 4908 may be replaced with, or enhanced by, the use of conventional hydraulic or mechanical slips.

[000458] In several exemplary embodiments of the system 4900, the expandable tubular sleeve 4922 is fabricated from materials particularly suited to being removed using a drilling device such as, for example, aluminum or brass.

[000459] In several exemplary embodiments of the system 4900, the float shoe 4926 may include a sliding sleeve valve for controlling the flow of fluidic materials through the float shoe. In several exemplary embodiments of the system 4900, the end of the expansion device assembly 4916 includes a conventional stinger attached thereto for manipulating and thereby controlling the operation of the sliding sleeve valve.

[000460] In several exemplary embodiments, the sealing cup assembly 4914 may be positioned above or below the casing lock assembly 4908.

[000461] Referring to Figs. 50a, 50aa, and 50ab, an exemplary embodiment of a system 5000 for radially expanding a tubular member includes a tubular support member 5002 that defines a passage 5002a, one or more radial openings 5002b, and one or more mounting holes 5002c, and includes an internal annular recess 5002d, an internal annular recess 5002e, and an internal annular recess 5002f. An end of a tubular support member 5004 that defines a passage 5004a, a mounting hole 5004b, a radial passage 5004c, a radial passage 5004d, a radial passage 5004e, and mounting hole 5004f, and includes an external annular recess 5004g, an external annular recess 5004h, an external annular recess 5004i including external circumferentially spaced apart splines 5004j, an external threaded connection 5004k, an external threaded connection 5004l, an external flange 5004m, a tapered external flange 5004n including circumferentially spaced apart T-shaped slots 5004o, and an external flange 5004p at another end including circumferentially spaced apart teeth 5004q, is received within and mates with the internal annular recess 5002d of the tubular support member 5002. In an exemplary embodiment, the tapered external flange 5004n of the tubular support member 5004 includes a plurality of faceted surfaces 5004na.

[000462] Locking dogs 5006 that include internal spaced-apart flanges, 5006a and 5006b, external locking teeth 5006c, and spring arms, 5006d and 5006e, for biasing the locking dogs radially inwardly, are received within and mate with corresponding radial openings 5002b of the tubular support member 5002. A tubular locking dog retainer sleeve 5008 that includes external spaced-apart flanges, 5008a and 5008b, positioned in opposition to the spaced-apart flanges, 5006a and 5006b, respectively, of the locking dogs 5006 receives and mates with an end of the tubular support member 5004.

[000463] An end of an expandable tubular member 5010 that includes internal teeth 5010a for engaging the external locking teeth 5006c of the locking dogs, and an upset portion 5010b, having a locally reduced internal diameter, adjacent another end, receives and mates with the tubular support member 5002. In several exemplary embodiments, the tubular member 5010 is provided and includes one or more of the properties of the expandable tubulars described above with reference to Figs. 1 to 46j. An end of an expansion sleeve 5012 that includes an internal threaded connection 5012a at one end is coupled to the other end of the expandable tubular member 5010. In several exemplary embodiments, the expansion sleeve 5012 is fabricated from aluminum and/or brass and/or alloys of one or both and/or includes one or more of the properties of the expandable tubulars described above with reference to Figs. 1 to 46j.

[000464] An end of an emergency release tubular sleeve 5014 that defines a radial passage 5014a and includes an internal annular recess 5014b that mates with the tubular support member 5004 receives and mates with the external annular recess 5004g of the end of the tubular support member 5004. A rupture disk 5016 is positioned within and coupled to the mounting hole 5004b of the tubular support member 5004.

[000465] An end of a tubular load transfer sleeve 5018 that defines a mounting hole 5018a and includes an external flange 5018b and an internal flange 5018c, including circumferentially spaced apart internal splines 5018d that mate with the external splines 5004j of the tubular support member 5004, at another end, mates with, is coupled to, and is received within the internal annular recess 5002f of the end of the tubular support member 5002. A mounting pin 5020 is received within and coupled to the mounting hole 5002c of the tubular support member 5002 and the mounting hole 5018a of the sleeve 5018 for transmitting torque loads there between.

[000466] An upper tubular sealing cup retainer 5022 that includes an internal threaded connection 5022a that is coupled to the external threaded connection 5004k of the tubular support member 5004 and an angled end face 5022b and an external tapered flange 5022c at another end that engages the interior surface of the expandable tubular member 5010 is positioned proximate an end face of the external splines 5004j of the tubular support member 5004.

[000467] A float shoe 5024 defines a passage 5024a having a throat 5024aa and a passage 5024b and includes an external annular recess 5024c, circumferentially spaced apart teeth 5024d for engaging the circumferentially spaced apart teeth 5004q of the tubular support member 5004, an external threaded connection 5024e coupled to the internal threaded connection 5012a of the end of the expansion sleeve 5012, and a conventional float element 5024f. A lower tubular sealing cup retainer 5026 that defines a plurality of circumferentially spaced apart internal longitudinal passages 5026a includes an internal threaded connection 5026b that is coupled to the external threaded connection 5004l of the tubular support member 5004.

[000468] A lower tubular cup seal support 5028 that receives, mates with, and is coupled to the tubular support member 5004 is positioned proximate the lower tubular sealing cup retainer 5026. A lower cup seal 5030 that receives, mates with, and is coupled to the tubular support member 5004 and sealingly engages the interior surface of the expandable tubular member 5010 is positioned proximate the lower tubular sealing cup retainer 5026. A lower cup seal support 5032 receives, mates with, and is coupled to the tubular support member 5004 and receives, mates with, and supports the lower cup seal 5030. A lower back-up cup seal 5034 that receives, mates with, and is coupled to the tubular support member 5004 and sealingly engages the interior surface of the expandable tubular member 5010 receives and mates with the lower cup seal 5030 and the lower cup seal support 5032. A lower tubular cup seal support 5036 that receives, mates with, and is coupled to the tubular support member 5004 is positioned proximate to, mates with, and supports, the lower back-up cup seal 5034.

[000469] An upper tubular cup seal support 5038 that receives, mates with, and is coupled to the

tubular support member 5004 is positioned proximate the lower tubular cup seal support 5036. An upper cup seal 5040 that receives, mates with, and is coupled to the tubular support member 5004 and sealingly engages the interior surface of the expandable tubular member 5010 is positioned proximate the upper tubular cup seal support 5038. An upper cup seal support 5042 receives, mates with, and is coupled to the tubular support member 5004 and receives, mates with, and supports the upper cup seal 5040. An upper back-up cup seal 5044 that receives, mates with, and is coupled to the tubular support member 5004 and sealingly engages the interior surface of the expandable tubular member 5010 receives and mates with the upper cup seal 5040 and the upper cup seal support 5042.

[000470] A tubular expansion cone retainer 5046 that defines circumferentially spaced apart internal passages 5046a that are fluidicly coupled to the circumferentially spaced apart internal longitudinal passages 5026a of the lower tubular sealing cup retainer 5026 and circumferentially spaced apart radially directed T-shaped grooves 5046b, and includes a tapered shoulder 5046c at one end and an internal annular recess 5046d that mates with and receives the external flange 5004m of the tubular support member 5004. A rupture disc 5048 is positioned within and coupled to the mounting hole 5004f of the tubular support member 5004.

[000471] Circumferentially spaced apart expansion cone segments 5050 include T-shaped mounting elements 5050a that are slidably received within and mate with corresponding T-shaped grooves 5046b of the tubular expansion cone retainer 5046 and T-shaped mounting elements 5050b that are slidably received within and mate with corresponding T-shaped slots 5004o of the tubular support member 5004. In an exemplary embodiment, each expansion cone segment 5050 is mounted upon a corresponding faceted surface 5004na of the tapered flange 5004n of the tubular support member 5004. In an exemplary embodiment, the expansion cone segments 5050 define a substantially contiguous outer expansion surface when displaced to a final radial outward position.

[000472] In an exemplary embodiment, the tubular support member 5004, the tubular expansion cone retainer 5046, and the expansion cone segments 5050 together provide an adjustable expansion device 5052. In several exemplary embodiments, the adjustable expansion device 5052, which provides expansion surfaces whose radial extent are adjustable, includes one or more elements of the adjustable expansion devices disclosed in WIPO International Publication WO 03/023178 A2, the disclosure of which is incorporated herein by reference.

[000473] In an exemplary embodiment, during operation of the system 5000, as illustrated in Figs. 50a, 50aa, and 50ab, the system is positioned within a wellbore 5054 that traverses a subterranean formation 5056. A hardenable fluidic sealing material 5058 such as, for example, cement may then be injected into the system 5000 through the passages 5002a, 5004a, and 5024a. The fluidic material 5058 may then be conveyed past the float element 5024f of the float shoe 5024 and through the passage 5024b into an annulus 5060 between the system 5000 and the interior surface of the wellbore 5054. The fluidic material 5058 within the annulus 5060 may then be allowed to at least partially cure.

[000474] In an exemplary embodiment, during the operation of the system 5000, as illustrated in Fig.

50b, a conventional plug 5062 is then positioned within the throat 5024aa of the passage 5024a of the float shoe 5024 by injecting fluidic material 5064 into the system 5000 through the passages 5002a, 5004a, and 5024a. As a result, the passage 5024a of the float shoe 5024 is blocked and the passages 5002a and 5004a may be pressurized by the continued injection of the fluidic material 5064.

[000475] In an exemplary embodiment, during the operation of the system 5000, as illustrated in Figs. 50c, 50ca, and 50cb, the passages 5002a and 5004a may be pressurized by the continued injection of the fluidic material 5064 into the system. As a result, the rupture disc 5048 is burst thereby permitting the pressurized fluidic material 5064 to be conveyed through the radial passage 5004f of the tubular support member 5004 and into the annulus defined between the tubular support member 5004 and the tubular expansion cone retainer 5046. As a result, the expansion cone segments 5050 are displaced in a longitudinal direction 5066. As a result, because the expansion cone segments 5050 are slidably mounted for movement on the T-shaped slots 5004o of the tapered external flange 5004n of the tubular support member 5004, the expansion cone segments 5050 are also displaced outwardly in a radial direction and thereby engage and radially expand and plastically deform the expansion sleeve 5012. In an exemplary embodiment, the outward radial displacement of the expansion cone segments 5050 also radially expands and plastically deforms the expandable tubular member 5010. In this manner, the size of the adjustable expansion device 5052 is increased.

[000476] In an exemplary experimental embodiment, the expansion sleeve 5012 is composed of 1018 steel and has a yield strength of 43,035 psi. Before the engagement between the expansion cone segments 5050 and the expansion sleeve 5012, the expansion sleeve 5012 has an outer diameter of 7.625 inches and an inner diameter of 6.875 inches. During the engagement between the expansion cone segments 5050 and the expansion sleeve 5012, and the corresponding radial expansion and plastic deformation of the expansion sleeve 5012 due to the engagement, the outer diameter defined by the expansion cone segments 5050 increases to 8.026 inches. The expansion force applied by the expansion cone segments 5050 to the expansion sleeve 5012 to substantially fully expand the expansion sleeve 5012 is 163,000 pounds.

[000477] In an exemplary experimental embodiment, the expansion sleeve 5012 is composed of C63200 aluminum nickel bronze and has a yield strength of 48,560 psi. Before the engagement between the expansion cone segments 5050 and the expansion sleeve 5012, the expansion sleeve 5012 has an outer diameter of 7.625 inches and an inner diameter of 6.875 inches. During the engagement between the expansion cone segments 5050 and the expansion sleeve 5012, and the corresponding radial expansion and plastic deformation of the expansion sleeve 5012 due to the engagement, the outer diameter defined by the expansion cone segments 5050 increases to 8.026 inches. The expansion force applied by the expansion cone segments 5050 to the expansion sleeve 5012 to substantially fully expand the expansion sleeve 5012 is 255,000 pounds.

[000478] In an exemplary experimental embodiment, the expansion sleeve 5012 is composed of 1018 steel and has a yield strength of 43,035 psi. Before the engagement between the expansion cone

segments 5050 and the expansion sleeve 5012, the expansion sleeve 5012 has an outer diameter of 7.625 inches and an inner diameter of 6.875 inches. During the engagement between the expansion cone segments 5050 and the expansion sleeve 5012, and the corresponding radial expansion and plastic deformation of the expansion sleeve 5012 due to the engagement, the outer diameter defined by the expansion cone segments 5050 increases to 8.500 inches. The expansion force applied by the expansion cone segments 5050 to the expansion sleeve 5012 to substantially fully expand the expansion sleeve 5012 is 227,000 pounds.

[000479] In an exemplary experimental embodiment, the expansion sleeve 5012 is composed of C63200 aluminum nickel bronze and has a yield strength of 48,560 psi. Before the engagement between the expansion cone segments 5050 and the expansion sleeve 5012, the expansion sleeve 5012 has an outer diameter of 7.625 inches and an inner diameter of 6.875 inches. During the engagement between the expansion cone segments 5050 and the expansion sleeve 5012, and the corresponding radial expansion and plastic deformation of the expansion sleeve 5012 due to the engagement, the outer diameter defined by the expansion cone segments 5050 increases to 8.500 inches. The expansion force applied by the expansion cone segments 5050 to the expansion sleeve 5012 to substantially fully expand the expansion sleeve 5012 is 346,000 pounds.

[000480] In several exemplary experimental embodiments, the expansion sleeve 5012 may be composed of a wide variety of materials such as, for example, all types of aluminum alloys, steel alloys, copper alloys and combinations thereof. Moreover, the expansion sleeve 5012 may be subjected to a wide variety of heat treatments and/or working processes such as, for example, cold working. As a result, it is understood that the yield strength of the expansion sleeve 5012 may vary significantly, and that other properties of the expansion sleeve 5012 may also vary significantly such as, for example, the strain hardening coefficient. Also, the material of the expansion sleeve 5012 may have the elongation to expand without splitting, and may be drillable with different types of drillbits such as, for example, toothed or PDC oilfield drillbits.

[000481] In an exemplary embodiment, during the operation of the system 5000, as illustrated in Fig. 50d, the passages 5002a and 5004a may continue to be pressurized by the continued injection of the fluidic material 5064 into the system. As a result, the pressurized fluidic material 5064 conveyed through the radial passage 5004f of the tubular support member 5004 and into the annulus defined between the tubular support member 5004 and the tubular expansion cone retainer 5046 pressurizes an annulus defined by the tubular support member 5004 and the expandable tubular member 5010 below the lower cup seal 5030. As a result, the pressurized fluidic material 5064 within the annulus defined by the tubular support member 5004 and the expandable tubular member 5010 below the lower cup seal 5030 applies a longitudinal force to the tubular support member 5004 in a direction 5068. As a result, the tubular support member 5004, the tubular sleeve 5014, and the locking dog retainer sleeve 5008 are displaced in the direction 5068 relative to the tubular support member 5002 and the locking dogs 5006 thereby releasing the flanges, 5006a and 5006b, of the locking dogs 5006 from engagement with the

flanges, 5008a and 5008b, of the locking dog retainer sleeve 5008. As a result, the spring arms, 5006d and 5006e, of the locking dogs 5006 displace the locking dogs radially inward and out of locking engagement with the expandable tubular member 5010. In this manner, the tubular support member 5004 is pulled by the lower cup seal 5030 in the direction 5068 relative to the expandable tubular member 5010. Furthermore, in this manner, a further portion of the expandable tubular member 5010 is radially expanded and plastically deformed by the adjustable expansion device 5052.

[000482] In an exemplary embodiment, during the operation of the system 5000, as illustrated in Fig. 50e, the passages 5002a and 5004a may continue to be pressurized by the continued injection of the fluidic material 5064 into the system. As a result, the pressurized fluidic material 5064 conveyed through the radial passage 5004f of the tubular support member 5004 and into the annulus defined between the tubular support member 5004 and the tubular expansion cone retainer 5046 continues to pressurize the annulus defined by the tubular support member 5004 and the expandable tubular member 5010 below the lower cup seal 5030. As a result, the pressurized fluidic material 5064 within the annulus defined by the tubular support member 5004 and the expandable tubular member 5010 below the lower cup seal 5030 continues to apply a longitudinal force to the tubular support member 5004 in the direction 5068. As a result, the tubular support member 5004 and the adjustable expansion device 5052 are displaced in the direction 5068 relative to the expandable tubular member 5010 thereby radially expanding and plastically deforming the expandable tubular member.

[000483] In an exemplary embodiment, as illustrated in Fig. 50f, following the placement of the plug 5062 within the throat 5024aa of the passage 5024a of the float shoe 5024, the expandable tubular member 5010 may be released from engagement with the locking dogs 5006. In particular, following the placement of the plug 5062 within the throat 5024aa of the passage 5024a of the float shoe 5024, the operating pressure of the injected fluidic material 5064 may be increased sufficiently to burst the rupture disk 5016 thereby permitting the fluidic material to be conveyed through the passage 5004b into the annulus defined between the tubular support member 5004 and the emergency release tubular sleeve 5014. As a result, the emergency release tubular sleeve 5014 is displaced in a direction 5070 relative to the tubular support member 5004. As a result, the locking dog retainer sleeve 5008 is displaced in the direction 5070 relative to the locking dogs 5006 thereby releasing the flanges, 5006a and 5006b, of the locking dogs 5006 from engagement with the flanges, 5008a and 5008b, of the locking dog retainer sleeve 5008. As a result, the spring arms, 5006d and 5006e, of the locking dogs 5006 displace the locking dogs radially inward and out of locking engagement with the expandable tubular member 5010. In this manner, the expandable tubular member 5010 may be controllably released from engagement with the locking dogs 5006.

[000484] In several exemplary embodiments, the tubular support member 5002 includes one or more elements of a conventional safety sub.

[000485] In several exemplary embodiments, the tubular support member 5002, the tubular support member 5004, the locking dogs 5006, and the locking dog retainer sleeve 5008 provide a locking

assembly for controllably locking the expandable tubular member 5010 to the tubular support member 5002. In several exemplary embodiments, conventional casing locking tools may be substituted for, or used in addition to, the locking assembly.

[000486] In several exemplary embodiments, the lower tubular cup seal support 5028, the lower cup seal 5030, the lower cup seal support 5032, the lower back-up cup seal 5034, the lower tubular cup seal support 5036, the upper tubular cup seal support 5038, the upper cup seal 5040, the upper cup seal support 5042, and the upper back-up cup seal 5044 provide a sealing assembly for sealing the interface between the tubular support member 5004 and the expandable tubular member 5010. In this manner, an annulus is defined between the tubular support member 5004 and the expandable tubular member 5010, below the sealing assembly, that may be pressurized thereby permitting the sealing assembly to apply a tensile upward force to the tubular support member 5004. In this manner, the tubular support member 5004 may be pulled upwardly out of the expandable tubular member 5010. Furthermore, in this manner, the adjustable expansion device 5052 may be pulled upwardly through the expandable tubular member 5010 to thereby radially expand and plastically deform the expandable tubular member.

[000487] In several exemplary embodiments, the adjustable expansion device 5052 is used to expand a portion of the expandable tubular member 5010 and/or the expandable sleeve 5012, and another expansion device, which may be fixed or adjustable in size, may be used to radially expand and plastically deform the remaining portions of the expandable tubular member and/or the expandable sleeve.

[000488] In several exemplary embodiments, the expandable sleeve 5012 is fabricated from a drillable material such as, for example, aluminum or copper, and is coupled to the end of the expandable tubular member 5010 by, for example, amorphous bonding. In an exemplary embodiment, the amount of force required to radially expand the expandable sleeve 5012 is significantly less than the amount of force required to radially expand the expandable tubular member 5010. In an exemplary embodiment, following the completion of the operations described above with reference to Figs. 50a to 50e, any unexpanded portions of the expandable sleeve 5012 are removed by, for example, drilling.

[000489] In an exemplary embodiment, the float element 5024f of the float shoe 5024 is fabricated from drillable materials such as, for example, aluminum, brass, composite materials, and/or concrete in order to facilitate its subsequent removal. In an exemplary embodiment, the float shoe 5024 includes a pressure balanced sliding sleeve valve, or other equivalent valve, to permit the control of the passage of fluidic materials through the passages of the float shoe, before or after the place of the plug 5062 within the throat 5024aa of the passage 5024a of the float shoe. In this manner, the hardenable fluidic sealing material 5058 may be injected into the annulus 5060 at any point during the operation of the system 5000.

[000490] In an alternative embodiment, the locking assembly may be released from engagement with the expandable tubular member 5010 before the size of the adjustable expansion device 5052 is increased.

[000491] In an exemplary embodiment, the adjustable expansion device 5052 includes a stinger for manipulating, and thereby controlling the operation of, the float shoe 5024.

[000492] In several exemplary embodiments, following the completion of the operations described above with reference to Figs. 50a to 50c, the tubular support members, 5002 and 5004, and the adjustably expansion device 5052 are lowered relative to the expandable tubular member 5010 and expandable sleeve 5012 thereby radially expanding and plastically deforming further portions of the expandable sleeve 5012. The adjustable expansion device 5052 is then displaced upwardly relative to the expandable tubular member as described above with reference to Figs. 50d and 50e.

[000493] In several exemplary embodiments, following the completion of the operations described above with reference to Figs. 50a to 50e, the tubular support members, 5002 and 5004, and the adjustably expansion device 5052 are lowered relative to the expandable tubular member 5010 and expandable sleeve 5012 thereby radially expanding and plastically deforming further portions of the expandable sleeve 5012.

[000494] In several exemplary embodiments, the operations of Figs. 50a to 50e may be repeated by overlapping a second expandable tubular member with the expandable tubular member 5010. In this manner, a wellbore casing, including a plurality of overlapping radially expanded wellbore casings, may be provided that has a constant internal diameter.

[000495] In an exemplary embodiment, a tribological system is used to reduce friction and thereby minimize the expansion forces required during the radial expansion and plastic deformation of the tubular members that includes one or more of the following: (1) a tubular tribology system; (2) a drilling mud tribology system; (3) a lubrication tribology system; and (4) an expansion device tribology system.

[000496] In an exemplary embodiment, the tubular tribology system includes the application of coatings of lubricant to the interior surface of the tubular members.

[000497] In an exemplary embodiment, the drilling mud tribology system includes the addition of lubricating additives to the drilling mud.

[000498] In an exemplary embodiment, the lubrication tribology system includes the use of lubricating greases, self-lubricating expansion devices, automated injection/delivery of lubricating greases into the interface between an expansion device and the tubular members, surfaces within the interface between the expansion device and the expandable tubular member that are self-lubricating, surfaces within the interface between the expansion device and the expandable tubular member that are textured, self-lubricating surfaces within the interface between the expansion device and the expandable tubular member that include diamond and/or ceramic inserts, thermosprayed coatings, fluoropolymer coatings, PVD films, and/or CVD films.

[000499] In an exemplary embodiment, the tubular members include one or more of the following characteristics: high burst and collapse, the ability to be radially expanded more than about 40%, high fracture toughness, defect tolerance, strain recovery @ 150 F, good bending fatigue, optimal residual stresses, and corrosion resistance to H2S in order to provide optimal characteristics during and after

radial expansion and plastic deformation.

[000500] In an exemplary embodiment, the tubular members are fabricated from a steel alloy having a charpy energy of at least about 90 ft-lbs in order to provided enhanced characteristics during and after radial expansion and plastic deformation of the expandable tubular member.

[000501] In an exemplary embodiment, the tubular members are fabricated from a steel alloy having a weight percentage of carbon of less than about 0.08% in order to provide enhanced characteristics during and after radial expansion and plastic deformation of the tubular members.

[000502] In an exemplary embodiment, the tubular members are fabricated from a steel alloy having reduced sulfur content in order to minimize hydrogen induced cracking.

[000503] In an exemplary embodiment, the tubular members are fabricated from a steel alloy having a weight percentage of carbon of less than about 0.20 % and a charpy-V-notch impact toughness of at least about 6 joules in order to provide enhanced characteristics during and after radial expansion and plastic deformation of the tubular members.

[000504] In an exemplary embodiment, the tubular members are fabricated from a steel alloy having a low weight percentage of carbon in order to enhance toughness, ductility, weldability, shelf energy, and hydrogen induced cracking resistance.

[000505] In several exemplary embodiments, the tubular members are fabricated from a steel alloy having the following percentage compositions in order to provide enhanced characteristics during and after radial expansion and plastic deformation of the tubular members:

| | C | Si | Mn | P | S | Al | N | Cu | Cr | Ni | Nb | Ti | Co | Mo |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EXAMPLE A | 0.030 | 0.22 | 1.74 | 0.005 | 0.0005 | 0.028 | 0.0037 | 0.30 | 0.26 | 0.15 | 0.095 | 0.014 | 0.0034 | |
| EXAMPLE B MIN | 0.020 | 0.23 | 1.70 | 0.004 | 0.0005 | 0.026 | 0.0030 | 0.27 | 0.26 | 0.16 | 0.096 | 0.012 | 0.0021 | |
| EXAMPLE B MAX | 0.032 | 0.26 | 1.92 | 0.009 | 0.0010 | 0.035 | 0.0047 | 0.32 | 0.29 | 0.18 | 0.120 | 0.016 | 0.0050 | |
| EXAMPLE C | 0.028 | 0.24 | 1.77 | 0.007 | 0.0008 | 0.030 | 0.0035 | 0.29 | 0.27 | 0.17 | 0.101 | 0.014 | 0.0028 | 0.0020 |
| EXAMPLE D | 0.08 | 0.30 | 0.5 | 0.07 | 0.005 | | 0.010 | 0.10 | 0.50 | 0.10 | | | | |
| EXAMPLE E | 0.0028 | 0.009 | 0.17 | 0.011 | 0.006 | 0.027 | 0.0029 | | 0.029 | 0.014 | 0.035 | 0.007 | | |
| EXAMPLE F | 0.03 | 0.1 | 0.1 | 0.015 | 0.005 | | | | | 18.0 | | 0.6 | 9 | 5 |
| EXAMPLE G | 0.002 | 0.01 | 0.15 | 0.07 | 0.005 | 0.04 | 0.0025 | | | | 0.015 | 0.010 | | |

[000506] In an exemplary embodiment, the ratio of the outside diameter D of the tubular members to the wall thickness t of the tubular members range from about 12 to 22 in order to enhance the collapse strength of the radially expanded and plastically deformed tubular members.

[000507] In an exemplary embodiment, the outer portion of the wall thickness of the radially expanded and plastically deformed tubular members includes tensile residual stresses in order to enhance the collapse strength following radial expansion and plastic deformation.

[000508] In several exemplary experimental embodiments, reducing residual stresses in samples of the tubular members prior to radial expansion and plastic deformation increased the collapse strength of the

radially expanded and plastically deformed tubular members.

[000509] In several exemplary experimental embodiments, the collapse strength of radially expanded and plastically deformed samples of the tubulars were determined on an as-received basis, after strain aging at 250 F for 5 hours to reduce residual stresses, and after strain aging at 350 F for 14 days to reduce residual stresses as follows:

| **Tubular Sample** | **Collapse Strength After 10% Radial Expansion** |
|---|---|
| Tubular Sample 1 – as received from manufacturer | 4000 psi |
| Tubular Sample 1 – strain aged at 250 F for 5 hours to reduce residual stresses | 4800 psi |
| Tubular Sample 1 – strain aged at 350 F for 14 days to reduce residual stresses | 5000 psi |

[000510] As indicated by the above table, reducing residual stresses in the tubular members, prior to radial expansion and plastic deformation, significantly increased the resulting collapse strength – post expansion.

[000511] In several exemplary experimental embodiments, the collapse strength of radially expanded and plastically deformed samples of the tubulars were determined on an as-received basis, after strain aging at 250 F for 5 hours to reduce residual stresses, and after strain aging at 350 F for 14 days to reduce residual stresses as follows:

| **Tubular Sample** | **Collapse Strength After 20% Radial Expansion** |
|---|---|
| **Tubular Sample 1 – as received from manufacturer** | 3000 psi |
| **Tubular Sample 1 – strain aged at 250 F for 5 hours to reduce residual stresses** | 4000 psi |
| **Tubular Sample 1 – strain aged at 350 F for 14 days to reduce residual stresses** | 4250 psi |

[000512] As indicated by the above table, reducing residual stresses in the tubular members, prior to radial expansion and plastic deformation, significantly increased the resulting collapse strength – post expansion.

[000513] In an exemplary experimental embodiment, residual stresses within a tubular member were decreased from about –12,000 psi to about –6,000 psi, a reduction of about 105%. As a result, the collapse strength of the resulting tubular member was increased from about 1550 psi to about 1750 psi. This was an unexpected result.

[000514] In several exemplary experimental embodiments, tubular members were radially expanded and plastically deformed using different lubricants to achieve a range of coefficients of friction between the tubular members and a solid expansion cone during the radial expansion and plastic deformation of the tubular members. As a result, the following experimental results were obtained:

| SAMPLE | COEFFICIENT OF FRICTION | EXPANSION FORCE (lbf) | WALL THICKNESS (t) | RATIO OF DIAMETER TO WALL THICKNESS AFTER EXPANSION (D/t) | COLLAPSE STRENGTH (ksi) |
|---|---|---|---|---|---|
| 1 | 0.125 | 145,900 | 0.305 | 24.8 | 2,379 |
| 2 | 0.075 | 143,000 | 0.350 | 21.6 | 3,243 |
| 3 | 0.02 | 149,900 | 0.450 | 16.8 | 5,837 |
| 4 | 0.02 | 125,800 | 0.500 | 15.1 | 5,359 |
| 5 | 0.02 | 125,800 | 0.500 | 15.1 | 8,443 |

The above tabular experimental results were unexpected. In particular, the resulting collapse strength of the radially expanded and plastically deformed tubular was increased by one or more of the following: 1) reducing the coefficient of friction; and/or 2) reducing the ratio of D/t.

[000515] Referring to Fig. 51, in an exemplary experimental embodiment, a sample of steel pipe, for which the normal manufacturing process was modified to include quenching and tempering (the "Quenched and Tempered Steel Pipe No. 1"), was tested to generate a stress vs. strain curve 5100. As illustrated in Fig. 51, the yield point of the curve 6700 was 76.8 ksi. Further stress and strain testing of the Quenched and Tempered Steel Pipe No. 1, yielded the following characteristics:

| Sample | Yield Strength ksi | Yield/Tensile Strength Ratio | Elongation Longitudinal % PRIOR TO FAILURE | Width Reduction % PRIOR TO FAILURE | Wall Thickness Reduction % PRIOR TO FAILURE | Anisotropy |
|---|---|---|---|---|---|---|
| Quenched and Tempered Steel Pipe No. 1 | 76.8 | 0.82 | 16% | 32% | 45% | 0.65 |

The testing results for the Quenched and Tempered Steel Pipe No. 1, illustrated in Fig. 51, and summarized above in tabular form were unexpected results. Thus, the modification of the normal manufacturing process of the Quenched and Tempered Steel Pipe No. 1, to include a quenching and tempering step, significantly and unexpectedly, enhanced the performance characteristics of the pipe thereby making the pipe particularly suited to use as an expandable tubular.

[000516] Referring to Fig. 52, in an exemplary experimental embodiment, a sample of 9 5/8" steel pipe, for which the normal manufacturing process was modified to include quenching and tempering (the "Quenched and Tempered Steel Pipe No. 2"), a sample of conventional 9 5/8" NT80-HE steel pipe from Nippon Steel, and a sample of conventional 9 5/8" NT55-HE steel pipe from Nippon Steel were tested to generate stress vs. strain curves 5200, 5202, and 5204, for the Quenched and Tempered Steel Pipe No. 2, the 9 5/8" NT80-HE steel pipe from Nippon Steel, and the 9 5/8" NT55-HE steel pipe from Nippon Steel,

respectively. As illustrated in Fig. 52, the yield points of the curves 5200, 5202, and 5204, were 84.4 ksi, 61.5 ksi, and 73.7 ksi, respectively. Further stress and strain testing of the Quenched and Tempered Steel Pipe No. 2, the 9 5/8" NT80-HE steel pipe from Nippon Steel, and the 9 5/8" NT55-HE steel pipe from Nippon Steel, yielded the following characteristics:

| Sample | Yield Strength ksi | Yield/Tensile Strength Ratio | Elongation Longitudinal % PRIOR TO FAILURE | Width Reduction % PRIOR TO FAILURE | Wall Thickness Reduction % PRIOR TO FAILURE | Anisotropy |
|---|---|---|---|---|---|---|
| Quenched and Tempered Steel Pipe No. 2 | 84.4 | 0.840 | 20.5% | 40.0% | 41.8% | 0.935 |
| NT80-HE | 61.5 | 0.62 | 16.5% | 25.5% | 47% | 0.46 |
| NT55-HE | 73.7 | 0.67 | 13.5% | 20.4% | 37.5% | 0.48 |

The testing results for the Quenched and Tempered Steel Pipe No. 2, illustrated in Fig. 52, and summarized above in tabular form were unexpected results. Thus, the modification of the normal manufacturing process of the Quenched and Tempered Steel Pipe No. 2, to include a quenching and tempering step, significantly and unexpectedly, enhanced the performance characteristics of the pipe, relative to the conventional NT80-HE and NT55-HE pipes, thereby making the pipe particularly suited to use as an expandable tubular.

[000517] In an exemplary experimental embodiment, samples of steel pipe, for which the normal manufacturing process was modified to include quenching and tempering (the "Quenched and Tempered Steel Pipe Nos. 3 and 4"), were stress and strain tested and exhibited the following characteristics:

| Characteristic | Value | |
|---|---|---|
| | Quenched and Tempered Steel Pipe No. 3 | Quenched and Tempered Steel Pipe No. 4 |
| YIELD STRENGTH | 81.25 ksi | 78.77 ksi |
| Y/T RATIO | 0.829 | 0.822 |
| ELONGATION PRIOR TO FAILURE | 14.88% | 15.90% |
| WIDTH REDUCTION PRIOR TO FAILURE | 37.8% | 44.0% |
| WALL THICKNESS REDUCTION PRIOR TO FAILURE | 43.25% | 43.33% |
| ANISOTROPY | 0.830 | 1.03 |

The tabular experimental results presented above were unexpected.

[000518] In an exemplary experimental embodiment, samples of steel pipe, for which the normal manufacturing process was modified to include quenching and tempering (the "Quenched and Tempered Steel Pipe No. 5"), were stress and strain tested and exhibited the following characteristics:

| Characteristic | Value |
|---|---|
| YIELD STRENGTH | 80.19 ksi |
| Y/T RATIO | 0.826 |
| ELONGATION PRIOR TO FAILURE | 15.25% |
| WIDTH REDUCTION PRIOR TO FAILURE | 40.4% |
| WALL THICKNESS REDUCTION PRIOR TO FAILURE | 43.3% |
| ANISOTROPY | 0.915 |

The tabular experimental results presented above were unexpected.

[000519] In an exemplary experimental embodiment, a sample of steel pipe, for which the normal manufacturing process was modified to include quenching and tempering (the "Quenched and Tempered Steel Pipe Nos. 6 and 7"), a sample of conventional NT80-HE steel pipe from Nippon Steel, and a sample of conventional NT55-HE steel pipe from Nippon Steel were tested to determine absorbed energy and flare expansion characteristics and exhibited the following characteristics:

| Characteristic | Value | | | |
|---|---|---|---|---|
| | Quenched and Tempered Steel Pipe No. 6 | Quenched and Tempered Steel Pipe No. 7 | NT80-HE | NT55-HE |
| ABSORBED ENERGY - LONGITUDINAL | 125 ft-lbs | 145 ft-lbs | 100 ft-lbs | 50 ft-lbs |
| ABSORBED ENERGY - TRANSVERSE | 59 ft-lbs | 59 ft-lbs | 40 ft-lbs | 30 ft-lbs |
| ABSORBED ENERGY - WELD | 176 ft-lbs | 174 ft-lbs | 70 ft-lbs | 4 ft-lbs |
| FLARE EXPANSION | 42% | 52% | 32% | 30% |

The testing results for the Quenched and Tempered Steel Pipe Nos. 6 and 7 summarized above in tabular form were unexpected results. Thus, the modification of the normal manufacturing process of the Quenched and Tempered Steel Pipe Nos. 6 and 7, to include a quenching and tempering step, significantly and unexpectedly, enhanced the performance characteristics of the pipe, relative to the conventional NT80-HE and NT55-HE pipes, thereby making the Quenched and Tempered Pipes particularly suited to use as an expandable tubular.

[000520] In an exemplary embodiment, the flare expansion of the Quenched and Tempered Steel Pipe Nos. 6 and 7, the sample of conventional NT80-HE steel pipe from Nippon Steel, and the sample of

conventional NT55-HE steel pipe from Nippon Steel were performed by pressing a tapered solid expansion cone into an end of the pipe samples to radially expand and plastically deform the ends of the pipe samples.

[000521] In an exemplary experimental embodiment, samples of steel pipe, for which the normal manufacturing process was modified to include quenching and tempering (the "Quenched and Tempered Steel Pipe No. 8"), were stress and strain tested and exhibited the following characteristics:

| Characteristic | Value |
|---|---|
| YIELD STRENGTH | 88.8 ksi |
| Y/T RATIO | 0.86 |
| ELONGATION PRIOR TO FAILURE | 22% |
| WIDTH REDUCTION PRIOR TO FAILURE | 39% |
| WALL THICKNESS REDUCTION PRIOR TO FAILURE | 41% |
| ANISOTROPY | 0.93 |

The tabular experimental results presented above were unexpected.

[000522] In an exemplary experimental embodiment, a sample of steel pipe, for which the normal manufacturing process was modified to include quenching and tempering (the "Quenched and Tempered Steel Pipe No. 9"), a sample of conventional NT80-HE steel pipe from Nippon Steel, and a sample of conventional NT55-HE steel pipe from Nippon Steel were tested to determine absorbed energy and flare expansion characteristics and exhibited the following characteristics:

| Characteristic | Value | | |
|---|---|---|---|
| | Quenched and Tempered Steel Pipe No. 9 | NT80-HE | NT55-HE |
| YIELD STRENGTH | 84.4 ksi | 73.7 ksi | 61.5 ksi |
| YIELD/TENSILE STRENGTH RATIO | 0.840 | 0.67 | 0.62 |
| ELONGATION BEFORE FAILURE | 20.5% | 13.5% | 16.5% |
| WIDTH REDUCTION BEFORE FAILURE | 40.0% | 20.4% | 25.5% |
| WALL THICKNESS REDUCTION BEFORE FAILURE | 41.8% | 37.5% | 47% |
| ANISOTROPY | 0.935 | 0.48 | 0.46 |

The testing results for the Quenched and Tempered Steel Pipe No. 9 summarized above in tabular form were unexpected results. Thus, the modification of the normal manufacturing process of the Quenched and Tempered Steel Pipe No. 9, to include a quenching and tempering step, significantly and unexpectedly, enhanced the performance characteristics of the pipe, relative to the conventional NT80-HE and NT55-HE pipes, thereby making the Quenched and Tempered Pipes particularly suited to use as an expandable tubular.

[000523] In an exemplary experimental embodiment, samples of steel pipe, for which the normal manufacturing process was modified to include quenching and tempering (the "Quenched and Tempered Steel Pipe No. 10"), were stress and strain tested and exhibited the following characteristics:

| Characteristic | Value |
|---|---|
| YIELD STRENGTH | 84.6 ksi |
| Y/T RATIO | 0.85 |
| ELONGATION PRIOR TO FAILURE | 21% |
| WIDTH REDUCTION PRIOR TO FAILURE | 39% |
| WALL THICKNESS REDUCTION PRIOR TO FAILURE | 43% |
| ANISOTROPY | 0.88 |

The tabular experimental results presented above were unexpected.

[000524] In an exemplary embodiment, the composition of the Quench and Temper Steel Pipe Nos. 1 to 10 included the following weight percentages:

| C | Si | Mn | P | S | Cu | Cr | Ni |
|---|---|---|---|---|---|---|---|
| 0.27 | 0.14 | 1.28 | 0.009 | 0.005 | | 0.14 | |

In an exemplary embodiment, the quenching of the Quench and Temper Steel Pipe Nos. 1 to 10 was provided at 970 C, and the tempering of the Quench and Temper Steel Pipe Nos. 1 to 10 was provided for 10 minutes at 670 C.

[000525] In an exemplary embodiment, using a combination of empirical, theoretical, and experimental data, electrical resistance pipe ("ERW") tubular members most suitable for radial expansion and plastic deformation exhibit the following characteristics:

| Characteristic | Value |
|---|---|
| ABSORBED ENERGY IN THE LONGITUDINAL DIRECTION | at least 80 ft-lb |
| ABSORBED ENERGY IN THE TRANSVERSE DIRECTION | at least 60 ft-lb |
| ABSORBED ENERGY IN THE TRANSVERSE WELD AREA | at least 60 ft-lb |
| FLARE EXPANSION | 45% to 75% MINIMUM W/O CRACKS |
| TENSILE STRENGTH | 60 TO 120 ksi |
| YIELD STRENGTH | 40 TO 100 ksi |
| Y/T RATIO | 40% to 85% MAXIMUM |
| LONGITUDINAL ELONGATION PRIOR TO FAILURE | A MINIMUM OF 22% to 35% |
| WIDTH REDUCTION PRIOR TO FAILURE | A MINIMUM OF 30% to 45% |
| WALL THICKNESS REDUCTION PRIOR TO FAILURE | A MINIMUM OF 30% to 45% |
| ANISOTROPY | A MINIMUM OF 0.8 to 1.5 |

[000526] In an exemplary experimental embodiment, based upon theoretical, empirical, and experimental data, tubular members that exhibit the following characteristics are best suited for radial expansion and plastic deformation:

| Characteristic | Value |
|---|---|
| YIELD STRENGTH | 50 to 95 ksi |
| Y/T RATIO | less than 0.5 to 0.82 |
| ELONGATION PRIOR TO FAILURE | greater than 16 to 30 % |
| WIDTH REDUCTION PRIOR TO FAILURE | greater than 32 to 45% |
| WALL THICKNESS REDUCTION PRIOR TO FAILURE | greater than 30 to 45% |
| ANISOTROPY | greater than 0.65 to 1.5 |

[000527] In an exemplary embodiment, as illustrated in Figs. 53 and 54, in an exemplary embodiment, a method 5300 of processing tubular members is implemented in which, in step 5302, a manufactured tubular member 5302a is received. In step 5304, the manufactured tubular member 5302a is then cold rolled to provide a cold-rolled tubular member 5304a. In step 5306, the cold-rolled tubular member 5304a is then inter critical annealed to provide an annealed tubular member 5306a. In step 5308, the annealed tubular member 5306a is then positioned within a wellbore and radially expanded and plastically deformed in a conventional manner to provide a radially expanded and plastically deformed tubular member 5308a. In step 5310, the radially expanded and plastically deformed tubular member 5308a is then baked within the wellbore, using the ambient temperatures within the wellbore, to provide an after-baked tubular member 5310a. As illustrated in Fig. 54, the ultimate and final yield strength of the after-baked tubular member 5310a is greater than the yield strength of the manufactured tubular member 5302a. In an exemplary embodiment, the manufactured tubular member 5302a is a dual phase steel pipe or a Transformation Induced Plasticity ("TRIP") steel pipe.

[000528] In an exemplary embodiment, the dual phase steel manufactured pipe 5302a includes a microstructure having about 15% to 30% martensite and ferrite. In an exemplary embodiment, the dual phase steel manufactured pipe 6902a includes a composition of 0.1% C, 1.2% Mn, and 0.3% Si.

[000529] In an exemplary embodiment, as illustrated in Fig. 55, when the manufactured pipe 5302a is a dual phase steel, the initial microstructure of the pipe includes ferrite and pearlite. In an exemplary embodiment, in step 5306, the intercritical annealing of the cold rolled pipe 5304a is performed at about 750 C. As a result of the intercritical annealing, at least some of the pearlite is converted to austentite. Following the completion of the intercritical annealing in step 5306, the annealed pipe 5306a is allowed to cool. As a result of the cooling, at least some of the austentite in the annealed pipe 5306a is converted to martensite. In an exemplary embodiment, in step 5310, the baking of the radially expanded and plastically deformed pipe 5308a is provided within the wellbore at temperatures

ranging from about 100 C to 250 C. In an exemplary embodiment, as a result of the baking step 5310, the radially expanded and plastically deformed pipe 6908a is stress-relieved and bake hardened.

[000530] In an exemplary embodiment, in step 5304 of the method 5300, as illustrated in Fig. 56, the temperature of the manufactured steel pipe 5302a follows a curve 5602 in which the steel pipe is deformed throughout the cooling progression of the curve at a plurality of separate stages, 5602a and 5602b. In an exemplary embodiment, during the first pipe rolling stage 5602a, insoluble precipitates within the pipe 5302a retard austentite growth and the deformation also promotes precipitation. In an exemplary embodiment, during the second pipe rolling state 5602b, insoluble precipitates within the pipe 6902a inhibit recrystallization and austentite grains are conditioned. As a result, the ultimate yield and collapse strength of the baked pipe 5310a is enhanced.

[000531] In several exemplary embodiments, the teachings of the present disclosure are combined with one or more of the teachings disclosed in FR 2 841 626, filed on 6/28/2002, and published on 1/2/2004, the disclosure of which is incorporated herein by reference.

[000532] A method of forming a tubular liner within a preexisting structure has been described that includes positioning a tubular assembly within the preexisting structure; and radially expanding and plastically deforming the tubular assembly within the preexisting structure, wherein, prior to the radial expansion and plastic deformation of the tubular assembly, a predetermined portion of the tubular assembly has a lower yield point than another portion of the tubular assembly. In an exemplary embodiment, the predetermined portion of the tubular assembly has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the predetermined portion of the tubular assembly has a higher ductility prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the predetermined portion of the tubular assembly has a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the predetermined portion of the tubular assembly has a larger inside diameter after the radial expansion and plastic deformation than other portions of the tubular assembly. In an exemplary embodiment, the method further includes positioning another tubular assembly within the preexisting structure in overlapping relation to the tubular assembly; and radially expanding and plastically deforming the other tubular assembly within the preexisting structure, wherein, prior to the radial expansion and plastic deformation of the tubular assembly, a predetermined portion of the other tubular assembly has a lower yield point than another portion of the other tubular assembly. In an exemplary embodiment, the inside diameter of the radially expanded and plastically deformed other portion of the tubular assembly is equal to the inside diameter of the radially expanded and plastically deformed other portion of the other tubular assembly. In an exemplary embodiment, the predetermined portion of the tubular assembly includes an end portion of the tubular assembly. In an exemplary embodiment, the predetermined portion of the tubular assembly includes a plurality of predetermined portions of the tubular assembly. In an exemplary embodiment, the

predetermined portion of the tubular assembly includes a plurality of spaced apart predetermined portions of the tubular assembly. In an exemplary embodiment, the other portion of the tubular assembly includes an end portion of the tubular assembly. In an exemplary embodiment, the other portion of the tubular assembly includes a plurality of other portions of the tubular assembly. In an exemplary embodiment, the other portion of the tubular assembly includes a plurality of spaced apart other portions of the tubular assembly. In an exemplary embodiment, the tubular assembly includes a plurality of tubular members coupled to one another by corresponding tubular couplings. In an exemplary embodiment, the tubular couplings include the predetermined portions of the tubular assembly; and wherein the tubular members comprise the other portion of the tubular assembly. In an exemplary embodiment, one or more of the tubular couplings include the predetermined portions of the tubular assembly. In an exemplary embodiment, one or more of the tubular members include the predetermined portions of the tubular assembly. In an exemplary embodiment, the predetermined portion of the tubular assembly defines one or more openings. In an exemplary embodiment, one or more of the openings include slots. In an exemplary embodiment, the anisotropy for the predetermined portion of the tubular assembly is greater than 1. In an exemplary embodiment, the anisotropy for the predetermined portion of the tubular assembly is greater than 1. In an exemplary embodiment, the strain hardening exponent for the predetermined portion of the tubular assembly is greater than 0.12. In an exemplary embodiment, the anisotropy for the predetermined portion of the tubular assembly is greater than 1; and the strain hardening exponent for the predetermined portion of the tubular assembly is greater than 0.12. In an exemplary embodiment, the predetermined portion of the tubular assembly is a first steel alloy including: 0.065 % C, 1.44 % Mn, 0.01 % P, 0.002 % S, 0.24 % Si, 0.01 % Cu, 0.01 % Ni, and 0.02 % Cr. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly is at most about 46.9 ksi prior to the radial expansion and plastic deformation; and the yield point of the predetermined portion of the tubular assembly is at least about 65.9 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly after the radial expansion and plastic deformation is at least about 40 % greater than the yield point of the predetermined portion of the tubular assembly prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is about 1.48. In an exemplary embodiment, the predetermined portion of the tubular assembly includes a second steel alloy including: 0.18 % C, 1.28 % Mn, 0.017 % P, 0.004 % S, 0.29 % Si, 0.01 % Cu, 0.01 % Ni, and 0.03 % Cr. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly is at most about 57.8 ksi prior to the radial expansion and plastic deformation; and the yield point of the predetermined portion of the tubular assembly is at least about 74.4 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly after the radial expansion and plastic deformation is at least about 28 % greater than the yield point of the predetermined portion of the tubular assembly prior to the radial expansion and plastic

deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is about 1.04. In an exemplary embodiment, the predetermined portion of the tubular assembly includes a third steel alloy including: 0.08 % C, 0.82 % Mn, 0.006 % P, 0.003 % S, 0.30 % Si, 0.16 % Cu, 0.05 % Ni, and 0.05 % Cr. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is about 1.92. In an exemplary embodiment, the predetermined portion of the tubular assembly includes a fourth steel alloy including: 0.02 % C, 1.31 % Mn, 0.02 % P, 0.001 % S, 0.45 % Si, 9.1 % Ni, and 18.7 % Cr. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is about 1.34. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly is at most about 46.9 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the tubular assembly is at least about 65.9 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly after the radial expansion and plastic deformation is at least about 40 % greater than the yield point of the predetermined portion of the tubular assembly prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is at least about 1.48. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly is at most about 57.8 ksi prior to the radial expansion and plastic deformation; and the yield point of the predetermined portion of the tubular assembly is at least about 74.4 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly after the radial expansion and plastic deformation is at least about 28 % greater than the yield point of the predetermined portion of the tubular assembly prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is at least about 1.04. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is at least about 1.92. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is at least about 1.34. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, ranges from about 1.04 to about 1.92. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, ranges from about 47.6 ksi to about 61.7 ksi. In an exemplary embodiment, the expandability coefficient of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is greater than 0.12. In an exemplary embodiment, the expandability coefficient of the predetermined portion of the tubular assembly is greater than the expandability coefficient of the other portion of the tubular assembly. In an exemplary embodiment, the tubular assembly includes a wellbore casing, a pipeline, or a structural support. In an

exemplary embodiment, the carbon content of the predetermined portion of the tubular assembly is less than or equal to 0.12 percent; and wherein the carbon equivalent value for the predetermined portion of the tubular assembly is less than 0.21. In an exemplary embodiment, the carbon content of the predetermined portion of the tubular assembly is greater than 0.12 percent; and wherein the carbon equivalent value for the predetermined portion of the tubular assembly is less than 0.36. In an exemplary embodiment, a yield point of an inner tubular portion of at least a portion of the tubular assembly is less than a yield point of an outer tubular portion of the portion of the tubular assembly. In an exemplary embodiment, yield point of the inner tubular portion of the tubular body varies as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies in an linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies in an non-linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the outer tubular portion of the tubular body varies as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the outer tubular portion of the tubular body varies in an linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the outer tubular portion of the tubular body varies in an non-linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies as a function of the radial position within the tubular body; and wherein the yield point of the outer tubular portion of the tubular body varies as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies in a linear fashion as a function of the radial position within the tubular body; and wherein the yield point of the outer tubular portion of the tubular body varies in a linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies in a linear fashion as a function of the radial position within the tubular body; and wherein the yield point of the outer tubular portion of the tubular body varies in a non-linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies in a non-linear fashion as a function of the radial position within the tubular body; and wherein the yield point of the outer tubular portion of the tubular body varies in a linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies in a non-linear fashion as a function of the radial position within the tubular body; and wherein the yield point of the outer tubular portion of the tubular body varies in a non-linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the rate of change of the yield point of the inner tubular portion of the tubular body is different than the rate of change of the yield point of the outer tubular portion of the tubular body. In an exemplary embodiment, the rate of change of the yield point of the inner tubular portion of the tubular body is different than the rate of change of the yield point

of the outer tubular portion of the tubular body. In an exemplary embodiment, prior to the radial expansion and plastic deformation, at least a portion of the tubular assembly comprises a microstructure comprising a hard phase structure and a soft phase structure. In an exemplary embodiment, prior to the radial expansion and plastic deformation, at least a portion of the tubular assembly comprises a microstructure comprising a transitional phase structure. In an exemplary embodiment, the hard phase structure comprises martensite. In an exemplary embodiment, the soft phase structure comprises ferrite. In an exemplary embodiment, the transitional phase structure comprises retained austentite. In an exemplary embodiment, the hard phase structure comprises martensite; wherein the soft phase structure comprises ferrite; and wherein the transitional phase structure comprises retained austentite. In an exemplary embodiment, the portion of the tubular assembly comprising a microstructure comprising a hard phase structure and a soft phase structure comprises, by weight percentage, about 0.1% C, about 1.2% Mn, and about 0.3% Si.

[000533] An expandable tubular member has been described that includes a steel alloy including: 0.065 % C, 1.44 % Mn, 0.01 % P, 0.002 % S, 0.24 % Si, 0.01 % Cu, 0.01 % Ni, and 0.02 % Cr. In an exemplary embodiment, a yield point of the tubular member is at most about 46.9 ksi prior to a radial expansion and plastic deformation; and a yield point of the tubular member is at least about 65.9 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the tubular member after the radial expansion and plastic deformation is at least about 40 % greater than the yield point of the tubular member prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the tubular member, prior to a radial expansion and plastic deformation, is about 1.48. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support.

[000534] An expandable tubular member has been described that includes a steel alloy including: 0.18 % C, 1.28 % Mn, 0.017 % P, 0.004 % S, 0.29 % Si, 0.01 % Cu, 0.01 % Ni, and 0.03 % Cr. In an exemplary embodiment, a yield point of the tubular member is at most about 57.8 ksi prior to a radial expansion and plastic deformation; and the yield point of the tubular member is at least about 74.4 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, a yield point of the of the tubular member after a radial expansion and plastic deformation is at least about 28 % greater than the yield point of the tubular member prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the tubular member, prior to a radial expansion and plastic deformation, is about 1.04. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support.

[000535] An expandable tubular member has been described that includes a steel alloy including: 0.08 % C, 0.82 % Mn, 0.006 % P, 0.003 % S, 0.30 % Si, 0.16 % Cu, 0.05 % Ni, and 0.05 % Cr. In an exemplary embodiment, the anisotropy of the tubular member, prior to a radial expansion and plastic deformation, is about 1.92. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support.

[000536] An expandable tubular member has been described that includes a steel alloy including: 0.02 % C, 1.31 % Mn, 0.02 % P, 0.001 % S, 0.45 % Si, 9.1 % Ni, and 18.7 % Cr. In an exemplary embodiment, the anisotropy of the tubular member, prior to a radial expansion and plastic deformation, is about 1.34. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support.

[000537] An expandable tubular member has been described, wherein the yield point of the expandable tubular member is at most about 46.9 ksi prior to a radial expansion and plastic deformation; and wherein the yield point of the expandable tubular member is at least about 65.9 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support.

[000538] An expandable tubular member has been described, wherein a yield point of the expandable tubular member after a radial expansion and plastic deformation is at least about 40 % greater than the yield point of the expandable tubular member prior to the radial expansion and plastic deformation. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support.

[000539] An expandable tubular member has been described, wherein the anisotropy of the expandable tubular member, prior to the radial expansion and plastic deformation, is at least about 1.48. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support.

[000540] An expandable tubular member has been described, wherein the yield point of the expandable tubular member is at most about 57.8 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the expandable tubular member is at least about 74.4 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support.

[000541] An expandable tubular member has been described, wherein the yield point of the expandable tubular member after a radial expansion and plastic deformation is at least about 28 % greater than the yield point of the expandable tubular member prior to the radial expansion and plastic deformation. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support.

[000542] An expandable tubular member has been described, wherein the anisotropy of the expandable tubular member, prior to the radial expansion and plastic deformation, is at least about 1.04. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support.

[000543] An expandable tubular member has been described, wherein the anisotropy of the expandable tubular member, prior to the radial expansion and plastic deformation, is at least about 1.92. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support.

[000544] An expandable tubular member has been described, wherein the anisotropy of the expandable tubular member, prior to the radial expansion and plastic deformation, is at least about 1.34. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support.

[000545] An expandable tubular member has been described, wherein the anisotropy of the expandable tubular member, prior to the radial expansion and plastic deformation, ranges from about 1.04 to about 1.92. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support.

[000546] An expandable tubular member has been described, wherein the yield point of the expandable tubular member, prior to the radial expansion and plastic deformation, ranges from about 47.6 ksi to about 61.7 ksi. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support.

[000547] An expandable tubular member has been described, wherein the expandability coefficient of the expandable tubular member, prior to the radial expansion and plastic deformation, is greater than 0.12. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support.

[000548] An expandable tubular member has been described, wherein the expandability coefficient of the expandable tubular member is greater than the expandability coefficient of another portion of the expandable tubular member. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support.

[000549] An expandable tubular member has been described, wherein the tubular member has a higher ductility and a lower yield point prior to a radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support.

[000550] A method of radially expanding and plastically deforming a tubular assembly including a first tubular member coupled to a second tubular member has been described that includes radially expanding and plastically deforming the tubular assembly within a preexisting structure; and using less power to radially expand each unit length of the first tubular member than to radially expand each unit length of the second tubular member. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support.

[000551] A system for radially expanding and plastically deforming a tubular assembly including a first tubular member coupled to a second tubular member has been described that includes means for radially expanding the tubular assembly within a preexisting structure; and means for using less power to radially expand each unit length of the first tubular member than required to radially expand each unit length of the second tubular member. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support.

[000552] A method of manufacturing a tubular member has been described that includes processing a tubular member until the tubular member is characterized by one or more intermediate characteristics; positioning the tubular member within a preexisting structure; and processing the tubular member within the preexisting structure until the tubular member is characterized one or more final characteristics. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support. In an exemplary embodiment, the preexisting structure includes a wellbore that traverses a subterranean formation. In an exemplary embodiment, the characteristics are selected from a group consisting of yield point and ductility. In an exemplary embodiment, processing the tubular member within the preexisting structure until the tubular member is characterized one or more final characteristics includes: radially expanding and plastically deforming the tubular member within the preexisting structure.

[000553] An apparatus has been described that includes an expandable tubular assembly; and an expansion device coupled to the expandable tubular assembly; wherein a predetermined portion of the expandable tubular assembly has a lower yield point than another portion of the expandable tubular assembly. In an exemplary embodiment, the expansion device includes a rotary expansion device, an axially displaceable expansion device, a reciprocating expansion device, a hydroforming expansion device, and/or an impulsive force expansion device. In an exemplary embodiment, the predetermined portion of the tubular assembly has a higher ductility and a lower yield point than another portion of the expandable tubular assembly. In an exemplary embodiment, the predetermined portion of the tubular assembly has a higher ductility than another portion of the expandable tubular assembly. In an exemplary embodiment, the predetermined portion of the tubular assembly has a lower yield point than another portion of the expandable tubular assembly. In an exemplary embodiment, the predetermined portion of the tubular assembly includes an end portion of the tubular assembly. In an exemplary embodiment, the predetermined portion of the tubular assembly includes a plurality of predetermined portions of the tubular assembly. In an exemplary embodiment, the predetermined portion of the tubular assembly includes a plurality of spaced apart predetermined portions of the tubular assembly. In an exemplary embodiment, the other portion of the tubular assembly includes an end portion of the tubular assembly. In an exemplary embodiment, the other portion of the tubular assembly includes a plurality of other portions of the tubular assembly. In an exemplary embodiment, the other portion of the tubular assembly includes a plurality of spaced apart other portions of the tubular assembly. In an exemplary embodiment, the tubular assembly includes a plurality of tubular members coupled to one another by corresponding tubular couplings. In an exemplary embodiment, the tubular couplings comprise the predetermined portions of the tubular assembly; and wherein the tubular members comprise the other portion of the tubular assembly. In an exemplary embodiment, one or more of the tubular couplings comprise the predetermined portions of the tubular assembly. In an exemplary embodiment, one or more of the tubular members comprise the predetermined portions of the tubular assembly. In an exemplary embodiment, the predetermined portion of the tubular assembly defines one or more openings. In an

exemplary embodiment, one or more of the openings comprise slots. In an exemplary embodiment, the anisotropy for the predetermined portion of the tubular assembly is greater than 1 In an exemplary embodiment, the anisotropy for the predetermined portion of the tubular assembly is greater than 1. In an exemplary embodiment, the strain hardening exponent for the predetermined portion of the tubular assembly is greater than 0.12. In an exemplary embodiment, the anisotropy for the predetermined portion of the tubular assembly is greater than 1; and wherein the strain hardening exponent for the predetermined portion of the tubular assembly is greater than 0.12. In an exemplary embodiment, the predetermined portion of the tubular assembly includes a first steel alloy including: 0.065 % C, 1.44 % Mn, 0.01 % P, 0.002 % S, 0.24 % Si, 0.01 % Cu, 0.01 % Ni, and 0.02 % Cr. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly is at most about 46.9 ksi. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly is about 1.48. In an exemplary embodiment, the predetermined portion of the tubular assembly includes a second steel alloy including: 0.18 % C, 1.28 % Mn, 0.017 % P, 0.004 % S, 0.29 % Si, 0.01 % Cu, 0.01 % Ni, and 0.03 % Cr. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly is at most about 57.8 ksi. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly is about 1.04. In an exemplary embodiment, the predetermined portion of the tubular assembly includes a third steel alloy including: 0.08 % C, 0.82 % Mn, 0.006 % P, 0.003 % S, 0.30 % Si, 0.16 % Cu, 0.05 % Ni, and 0.05 % Cr. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly is about 1.92. In an exemplary embodiment, the predetermined portion of the tubular assembly includes a fourth steel alloy including: 0.02 % C, 1.31 % Mn, 0.02 % P, 0.001 % S, 0.45 % Si, 9.1 % Ni, and 18.7 % Cr. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly is at least about 1.34. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly is at most about 46.9 ksi. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly is at least about 1.48. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly is at most about 57.8 ksi. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly is at least about 1.04. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly is at least about 1.92. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly is at least about 1.34. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly ranges from about 1.04 to about 1.92. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly ranges from about 47.6 ksi to about 61.7 ksi. In an exemplary embodiment, the expandability coefficient of the predetermined portion of the tubular assembly is greater than 0.12. In an exemplary embodiment, the expandability coefficient of the predetermined portion of the tubular assembly is greater than the expandability coefficient of the other portion of the tubular assembly. In an exemplary embodiment, the tubular assembly includes a wellbore casing, a pipeline, or a structural support. In an exemplary embodiment, the carbon content of the

predetermined portion of the tubular assembly is less than or equal to 0.12 percent; and wherein the carbon equivalent value for the predetermined portion of the tubular assembly is less than 0.21. In an exemplary embodiment, the carbon content of the predetermined portion of the tubular assembly is greater than 0.12 percent; and wherein the carbon equivalent value for the predetermined portion of the tubular assembly is less than 0.36. In an exemplary embodiment, a yield point of an inner tubular portion of at least a portion of the tubular assembly is less than a yield point of an outer tubular portion of the portion of the tubular assembly. In an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies in an linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies in an non-linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the outer tubular portion of the tubular body varies as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the outer tubular portion of the tubular body varies in an linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the outer tubular portion of the tubular body varies in an non-linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies as a function of the radial position within the tubular body; and wherein the yield point of the outer tubular portion of the tubular body varies as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies in a linear fashion as a function of the radial position within the tubular body; and wherein the yield point of the outer tubular portion of the tubular body varies in a linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies in a linear fashion as a function of the radial position within the tubular body; and wherein the yield point of the outer tubular portion of the tubular body varies in a non-linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies in a non-linear fashion as a function of the radial position within the tubular body; and wherein the yield point of the outer tubular portion of the tubular body varies in a linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies in a non-linear fashion as a function of the radial position within the tubular body; and wherein the yield point of the outer tubular portion of the tubular body varies in a non-linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the rate of change of the yield point of the inner tubular portion of the tubular body is different than the rate of change of the yield point of the outer tubular portion of the tubular body. In an exemplary embodiment, the rate of change of the yield point of the inner tubular portion of the tubular body is different than the rate of change of the yield point of the outer tubular portion of the tubular body. In an

exemplary embodiment, at least a portion of the tubular assembly comprises a microstructure comprising a hard phase structure and a soft phase structure. In an exemplary embodiment, prior to the radial expansion and plastic deformation, at least a portion of the tubular assembly comprises a microstructure comprising a transitional phase structure. In an exemplary embodiment, wherein the hard phase structure comprises martensite. In an exemplary embodiment, wherein the soft phase structure comprises ferrite. In an exemplary embodiment, wherein the transitional phase structure comprises retained austentite. In an exemplary embodiment, the hard phase structure comprises martensite; wherein the soft phase structure comprises ferrite; and wherein the transitional phase structure comprises retained austentite. In an exemplary embodiment, the portion of the tubular assembly comprising a microstructure comprising a hard phase structure and a soft phase structure comprises, by weight percentage, about 0.1% C, about 1.2% Mn, and about 0.3% Si. In an exemplary embodiment, at least a portion of the tubular assembly comprises a microstructure comprising a hard phase structure and a soft phase structure. In an exemplary embodiment, the portion of the tubular assembly comprises, by weight percentage, 0.065% C, 1.44% Mn, 0.01% P, 0.002% S, 0.24% Si, 0.01% Cu, 0.01% Ni, 0.02% Cr, 0.05% V, 0.01% Mo, 0.01% Nb, and 0.01%Ti. In an exemplary embodiment, the portion of the tubular assembly comprises, by weight percentage, 0.18% C, 1.28% Mn, 0.017% P, 0.004% S, 0.29% Si, 0.01% Cu, 0.01% Ni, 0.03% Cr, 0.04% V, 0.01% Mo, 0.03% Nb, and 0.01%Ti. In an exemplary embodiment, the portion of the tubular assembly comprises, by weight percentage, 0.08% C, 0.82% Mn, 0.006% P, 0.003% S, 0.30% Si, 0.06% Cu, 0.05% Ni, 0.05% Cr, 0.03% V, 0.03% Mo, 0.01% Nb, and 0.01%Ti. In an exemplary embodiment, the portion of the tubular assembly comprises a microstructure comprising one or more of the following: martensite, pearlite, vanadium carbide, nickel carbide, or titanium carbide. In an exemplary embodiment, the portion of the tubular assembly comprises a microstructure comprising one or more of the following: pearlite or pearlite striation. In an exemplary embodiment, the portion of the tubular assembly comprises a microstructure comprising one or more of the following: grain pearlite, widmanstatten martensite, vanadium carbide, nickel carbide, or titanium carbide. In an exemplary embodiment, the portion of the tubular assembly comprises a microstructure comprising one or more of the following: ferrite, grain pearlite, or martensite. In an exemplary embodiment, the portion of the tubular assembly comprises a microstructure comprising one or more of the following: ferrite, martensite, or bainite. In an exemplary embodiment, the portion of the tubular assembly comprises a microstructure comprising one or more of the following: bainite, pearlite, or ferrite. In an exemplary embodiment, the portion of the tubular assembly comprises a yield strength of about 67ksi and a tensile strength of about 95 ksi. In an exemplary embodiment, the portion of the tubular assembly comprises a yield strength of about 82 ksi and a tensile strength of about 130 ksi. In an exemplary embodiment, the portion of the tubular assembly comprises a yield strength of about 60 ksi and a tensile strength of about 97 ksi.

[000554] An expandable tubular member has been described, wherein a yield point of the expandable tubular member after a radial expansion and plastic deformation is at least about 5.8 % greater than the yield point of the expandable tubular member prior to the radial expansion and plastic

deformation. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support.

[000555] A method of determining the expandability of a selected tubular member has been described that includes determining an anisotropy value for the selected tubular member, determining a strain hardening value for the selected tubular member; and multiplying the anisotropy value times the strain hardening value to generate an expandability value for the selected tubular member. In an exemplary embodiment, an anisotropy value greater than 0.12 indicates that the tubular member is suitable for radial expansion and plastic deformation. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support.

[000556] A method of radially expanding and plastically deforming tubular members has been described that includes selecting a tubular member; determining an anisotropy value for the selected tubular member; determining a strain hardening value for the selected tubular member; multiplying the anisotropy value times the strain hardening value to generate an expandability value for the selected tubular member; and if the anisotropy value is greater than 0.12, then radially expanding and plastically deforming the selected tubular member. In an exemplary embodiment, the tubular member includes a wellbore casing, a pipeline, or a structural support. In an exemplary embodiment, radially expanding and plastically deforming the selected tubular member includes: inserting the selected tubular member into a preexisting structure; and then radially expanding and plastically deforming the selected tubular member. In an exemplary embodiment, the preexisting structure includes a wellbore that traverses a subterranean formation.

[000557] A radially expandable multiple tubular member apparatus has been described that includes a first tubular member; a second tubular member engaged with the first tubular member forming a joint; a sleeve overlapping and coupling the first and second tubular members at the joint; the sleeve having opposite tapered ends and a flange engaged in a recess formed in an adjacent tubular member; and one of the tapered ends being a surface formed on the flange. In an exemplary embodiment, the recess includes a tapered wall in mating engagement with the tapered end formed on the flange. In an exemplary embodiment, the sleeve includes a flange at each tapered end and each tapered end is formed on a respective flange. In an exemplary embodiment, each tubular member includes a recess. In an exemplary embodiment, each flange is engaged in a respective one of the recesses. In an exemplary embodiment, each recess includes a tapered wall in mating engagement with the tapered end formed on a respective one of the flanges.

[000558] A method of joining radially expandable multiple tubular members has also been described that includes providing a first tubular member; engaging a second tubular member with the first tubular member to form a joint; providing a sleeve having opposite tapered ends and a flange, one of the tapered ends being a surface formed on the flange; and mounting the sleeve for overlapping and coupling the first and second tubular members at the joint, wherein the flange is engaged in a recess formed in an adjacent one of the tubular members. In an exemplary embodiment, the method further includes

providing a tapered wall in the recess for mating engagement with the tapered end formed on the flange. In an exemplary embodiment, the method further includes providing a flange at each tapered end wherein each tapered end is formed on a respective flange. In an exemplary embodiment, the method further includes providing a recess in each tubular member. In an exemplary embodiment, the method further includes engaging each flange in a respective one of the recesses. In an exemplary embodiment, the method further includes providing a tapered wall in each recess for mating engagement with the tapered end formed on a respective one of the flanges.

[000559] A radially expandable multiple tubular member apparatus has been described that includes a first tubular member; a second tubular member engaged with the first tubular member forming a joint; and a sleeve overlapping and coupling the first and second tubular members at the joint; wherein at least a portion of the sleeve is comprised of a frangible material.

[000560] A radially expandable multiple tubular member apparatus has been described that includes a first tubular member; a second tubular member engaged with the first tubular member forming a joint; and a sleeve overlapping and coupling the first and second tubular members at the joint; wherein the wall thickness of the sleeve is variable.

[000561] A method of joining radially expandable multiple tubular members has been described that includes providing a first tubular member; engaging a second tubular member with the first tubular member to form a joint; providing a sleeve comprising a frangible material; and mounting the sleeve for overlapping and coupling the first and second tubular members at the joint.

[000562] A method of joining radially expandable multiple tubular members has been described that includes providing a first tubular member; engaging a second tubular member with the first tubular member to form a joint; providing a sleeve comprising a variable wall thickness; and mounting the sleeve for overlapping and coupling the first and second tubular members at the joint.

[000563] An expandable tubular assembly has been described that includes a first tubular member; a second tubular member coupled to the first tubular member; and means for increasing the axial compression loading capacity of the coupling between the first and second tubular members before and after a radial expansion and plastic deformation of the first and second tubular members.

[000564] An expandable tubular assembly has been described that includes a first tubular member; a second tubular member coupled to the first tubular member; and means for increasing the axial tension loading capacity of the coupling between the first and second tubular members before and after a radial expansion and plastic deformation of the first and second tubular members.

[000565] An expandable tubular assembly has been described that includes a first tubular member; a second tubular member coupled to the first tubular member; and means for increasing the axial compression and tension loading capacity of the coupling between the first and second tubular members before and after a radial expansion and plastic deformation of the first and second tubular members.

[000566] An expandable tubular assembly has been described that includes a first tubular member; a second tubular member coupled to the first tubular member; and means for avoiding stress risers in the

coupling between the first and second tubular members before and after a radial expansion and plastic deformation of the first and second tubular members.

[000567] An expandable tubular assembly has been described that includes a first tubular member; a second tubular member coupled to the first tubular member; and means for inducing stresses at selected portions of the coupling between the first and second tubular members before and after a radial expansion and plastic deformation of the first and second tubular members.

[000568] In several exemplary embodiments of the apparatus described above, the sleeve is circumferentially tensioned; and wherein the first and second tubular members are circumferentially compressed.

[000569] In several exemplary embodiments of the method described above, the method further includes maintaining the sleeve in circumferential tension; and maintaining the first and second tubular members in circumferential compression before, during, and/or after the radial expansion and plastic deformation of the first and second tubular members.

[000570] An expandable tubular assembly has been described that includes a first tubular member, a second tubular member coupled to the first tubular member, a first threaded connection for coupling a portion of the first and second tubular members, a second threaded connection spaced apart from the first threaded connection for coupling another portion of the first and second tubular members, a tubular sleeve coupled to and receiving end portions of the first and second tubular members, and a sealing element positioned between the first and second spaced apart threaded connections for sealing an interface between the first and second tubular member, wherein the sealing element is positioned within an annulus defined between the first and second tubular members. In an exemplary embodiment, the annulus is at least partially defined by an irregular surface. In an exemplary embodiment, the annulus is at least partially defined by a toothed surface. In an exemplary embodiment, the sealing element comprises an elastomeric material. In an exemplary embodiment, the sealing element comprises a metallic material. In an exemplary embodiment, the sealing element comprises an elastomeric and a metallic material.

[000571] A method of joining radially expandable multiple tubular members has been described that includes providing a first tubular member, providing a second tubular member, providing a sleeve, mounting the sleeve for overlapping and coupling the first and second tubular members, threadably coupling the first and second tubular members at a first location, threadably coupling the first and second tubular members at a second location spaced apart from the first location, and sealing an interface between the first and second tubular members between the first and second locations using a compressible sealing element. In an exemplary embodiment, the sealing element includes an irregular surface. In an exemplary embodiment, the sealing element includes a toothed surface. In an exemplary embodiment, the sealing element comprises an elastomeric material. In an exemplary embodiment, the sealing element comprises a metallic material. In an exemplary embodiment, the sealing element comprises an elastomeric and a metallic material.

[000572] An expandable tubular assembly has been described that includes a first tubular member, a second tubular member coupled to the first tubular member, a first threaded connection for coupling a portion of the first and second tubular members, a second threaded connection spaced apart from the first threaded connection for coupling another portion of the first and second tubular members, and a plurality of spaced apart tubular sleeves coupled to and receiving end portions of the first and second tubular members. In an exemplary embodiment, at least one of the tubular sleeves is positioned in opposing relation to the first threaded connection; and wherein at least one of the tubular sleeves is positioned in opposing relation to the second threaded connection. In an exemplary embodiment, at least one of the tubular sleeves is not positioned in opposing relation to the first and second threaded connections.

[000573] A method of joining radially expandable multiple tubular members has been described that includes providing a first tubular member, providing a second tubular member, threadably coupling the first and second tubular members at a first location, threadably coupling the first and second tubular members at a second location spaced apart from the first location, providing a plurality of sleeves, and mounting the sleeves at spaced apart locations for overlapping and coupling the first and second tubular members. In an exemplary embodiment, at least one of the tubular sleeves is positioned in opposing relation to the first threaded coupling; and wherein at least one of the tubular sleeves is positioned in opposing relation to the second threaded coupling. In an exemplary embodiment, at least one of the tubular sleeves is not positioned in opposing relation to the first and second threaded couplings.

[000574] An expandable tubular assembly has been described that includes a first tubular member, a second tubular member coupled to the first tubular member, and a plurality of spaced apart tubular sleeves coupled to and receiving end portions of the first and second tubular members.

[000575] A method of joining radially expandable multiple tubular members has been described that includes providing a first tubular member, providing a second tubular member, providing a plurality of sleeves, coupling the first and second tubular members, and mounting the sleeves at spaced apart locations for overlapping and coupling the first and second tubular members.

[000576] An expandable tubular assembly has been described that includes a first tubular member, a second tubular member coupled to the first tubular member, a threaded connection for coupling a portion of the first and second tubular members, and a tubular sleeves coupled to and receiving end portions of the first and second tubular members, wherein at least a portion of the threaded connection is upset. In an exemplary embodiment, at least a portion of tubular sleeve penetrates the first tubular member.

[000577] A method of joining radially expandable multiple tubular members has been described that includes providing a first tubular member, providing a second tubular member, threadably coupling the first and second tubular members, and upsetting the threaded coupling. In an exemplary embodiment, the first tubular member further comprises an annular extension extending therefrom, and the flange of the sleeve defines an annular recess for receiving and mating with the annular extension of the first tubular member. In an exemplary embodiment, the first tubular member further comprises an annular

extension extending therefrom; and the flange of the sleeve defines an annular recess for receiving and mating with the annular extension of the first tubular member.

[000578] A radially expandable multiple tubular member apparatus has been described that includes a first tubular member, a second tubular member engaged with the first tubular member forming a joint, a sleeve overlapping and coupling the first and second tubular members at the joint, and one or more stress concentrators for concentrating stresses in the joint. In an exemplary embodiment, one or more of the stress concentrators comprises one or more external grooves defined in the first tubular member. In an exemplary embodiment, one or more of the stress concentrators comprises one or more internal grooves defined in the second tubular member. In an exemplary embodiment, one or more of the stress concentrators comprises one or more openings defined in the sleeve. In an exemplary embodiment, one or more of the stress concentrators comprises one or more external grooves defined in the first tubular member; and one or more of the stress concentrators comprises one or more internal grooves defined in the second tubular member. In an exemplary embodiment, one or more of the stress concentrators comprises one or more external grooves defined in the first tubular member; and one or more of the stress concentrators comprises one or more openings defined in the sleeve. In an exemplary embodiment, one or more of the stress concentrators comprises one or more internal grooves defined in the second tubular member; and one or more of the stress concentrators comprises one or more openings defined in the sleeve. In an exemplary embodiment, one or more of the stress concentrators comprises one or more external grooves defined in the first tubular member; wherein one or more of the stress concentrators comprises one or more internal grooves defined in the second tubular member; and wherein one or more of the stress concentrators comprises one or more openings defined in the sleeve.

[000579] A method of joining radially expandable multiple tubular members has been described that includes providing a first tubular member, engaging a second tubular member with the first tubular member to form a joint, providing a sleeve having opposite tapered ends and a flange, one of the tapered ends being a surface formed on the flange, and concentrating stresses within the joint. In an exemplary embodiment, concentrating stresses within the joint comprises using the first tubular member to concentrate stresses within the joint. In an exemplary embodiment, concentrating stresses within the joint comprises using the second tubular member to concentrate stresses within the joint. In an exemplary embodiment, concentrating stresses within the joint comprises using the sleeve to concentrate stresses within the joint. In an exemplary embodiment, concentrating stresses within the joint comprises using the first tubular member and the second tubular member to concentrate stresses within the joint. In an exemplary embodiment, concentrating stresses within the joint comprises using the first tubular member and the sleeve to concentrate stresses within the joint. In an exemplary embodiment, concentrating stresses within the joint comprises using the second tubular member and the sleeve to concentrate stresses within the joint. In an exemplary embodiment, concentrating stresses within the joint comprises using the first tubular member, the second tubular member, and the sleeve to concentrate stresses within the joint.

[000580] A system for radially expanding and plastically deforming a first tubular member coupled to a second tubular member by a mechanical connection has been described that includes means for radially expanding the first and second tubular members, and means for maintaining portions of the first and second tubular member in circumferential compression following the radial expansion and plastic deformation of the first and second tubular members.

[000581] A system for radially expanding and plastically deforming a first tubular member coupled to a second tubular member by a mechanical connection has been described that includes means for radially expanding the first and second tubular members; and means for concentrating stresses within the mechanical connection during the radial expansion and plastic deformation of the first and second tubular members.

[000582] A system for radially expanding and plastically deforming a first tubular member coupled to a second tubular member by a mechanical connection has been described that includes means for radially expanding the first and second tubular members; means for maintaining portions of the first and second tubular member in circumferential compression following the radial expansion and plastic deformation of the first and second tubular members; and means for concentrating stresses within the mechanical connection during the radial expansion and plastic deformation of the first and second tubular members.

[000583] A radially expandable tubular member apparatus has been described that includes a first tubular member; a second tubular member engaged with the first tubular member forming a joint; and a sleeve overlapping and coupling the first and second tubular members at the joint; wherein, prior to a radial expansion and plastic deformation of the apparatus, a predetermined portion of the apparatus has a lower yield point than another portion of the apparatus. In an exemplary embodiment, the carbon content of the predetermined portion of the apparatus is less than or equal to 0.12 percent; and wherein the carbon equivalent value for the predetermined portion of the apparatus is less than 0.21. In an exemplary embodiment, the carbon content of the predetermined portion of the apparatus is greater than 0.12 percent; and wherein the carbon equivalent value for the predetermined portion of the apparatus is less than 0.36. In an exemplary embodiment, the apparatus further includes means for maintaining portions of the first and second tubular member in circumferential compression following the radial expansion and plastic deformation of the first and second tubular members. In an exemplary embodiment, the apparatus further includes means for concentrating stresses within the mechanical connection during the radial expansion and plastic deformation of the first and second tubular members. In an exemplary embodiment, the apparatus further includes means for maintaining portions of the first and second tubular member in circumferential compression following the radial expansion and plastic deformation of the first and second tubular members; and means for concentrating stresses within the mechanical connection during the radial expansion and plastic deformation of the first and second tubular members. In an exemplary embodiment, the apparatus further includes one or more stress concentrators for concentrating stresses in the joint. In an exemplary embodiment, one or more of the stress concentrators comprises one

or more external grooves defined in the first tubular member. In an exemplary embodiment, one or more of the stress concentrators comprises one or more internal grooves defined in the second tubular member. In an exemplary embodiment, one or more of the stress concentrators comprises one or more openings defined in the sleeve. In an exemplary embodiment, one or more of the stress concentrators comprises one or more external grooves defined in the first tubular member; and wherein one or more of the stress concentrators comprises one or more internal grooves defined in the second tubular member. In an exemplary embodiment, one or more of the stress concentrators comprises one or more external grooves defined in the first tubular member; and wherein one or more of the stress concentrators comprises one or more openings defined in the sleeve. In an exemplary embodiment, one or more of the stress concentrators comprises one or more internal grooves defined in the second tubular member; and wherein one or more of the stress concentrators comprises one or more openings defined in the sleeve. In an exemplary embodiment, one or more of the stress concentrators comprises one or more external grooves defined in the first tubular member; wherein one or more of the stress concentrators comprises one or more internal grooves defined in the second tubular member; and wherein one or more of the stress concentrators comprises one or more openings defined in the sleeve. In an exemplary embodiment, the first tubular member further comprises an annular extension extending therefrom; and wherein the flange of the sleeve defines an annular recess for receiving and mating with the annular extension of the first tubular member. In an exemplary embodiment, the apparatus further includes a threaded connection for coupling a portion of the first and second tubular members; wherein at least a portion of the threaded connection is upset. In an exemplary embodiment, at least a portion of tubular sleeve penetrates the first tubular member. In an exemplary embodiment, the apparatus further includes means for increasing the axial compression loading capacity of the joint between the first and second tubular members before and after a radial expansion and plastic deformation of the first and second tubular members. In an exemplary embodiment, the apparatus further includes means for increasing the axial tension loading capacity of the joint between the first and second tubular members before and after a radial expansion and plastic deformation of the first and second tubular members. In an exemplary embodiment, the apparatus further includes means for increasing the axial compression and tension loading capacity of the joint between the first and second tubular members before and after a radial expansion and plastic deformation of the first and second tubular members. In an exemplary embodiment, the apparatus further includes means for avoiding stress risers in the joint between the first and second tubular members before and after a radial expansion and plastic deformation of the first and second tubular members. In an exemplary embodiment, the apparatus further includes means for inducing stresses at selected portions of the coupling between the first and second tubular members before and after a radial expansion and plastic deformation of the first and second tubular members. In an exemplary embodiment, the sleeve is circumferentially tensioned; and wherein the first and second tubular members are circumferentially compressed. In an exemplary embodiment, the means for increasing the axial compression loading capacity of the coupling between the first and second tubular members before and after a radial

expansion and plastic deformation of the first and second tubular members is circumferentially tensioned; and wherein the first and second tubular members are circumferentially compressed. In an exemplary embodiment, the means for increasing the axial tension loading capacity of the coupling between the first and second tubular members before and after a radial expansion and plastic deformation of the first and second tubular members is circumferentially tensioned; and wherein the first and second tubular members are circumferentially compressed. In an exemplary embodiment, the means for increasing the axial compression and tension loading capacity of the coupling between the first and second tubular members before and after a radial expansion and plastic deformation of the first and second tubular members is circumferentially tensioned; and wherein the first and second tubular members are circumferentially compressed. In an exemplary embodiment, the means for avoiding stress risers in the coupling between the first and second tubular members before and after a radial expansion and plastic deformation of the first and second tubular members is circumferentially tensioned; and wherein the first and second tubular members are circumferentially compressed. In an exemplary embodiment, the means for inducing stresses at selected portions of the coupling between the first and second tubular members before and after a radial expansion and plastic deformation of the first and second tubular members is circumferentially tensioned; and wherein the first and second tubular members are circumferentially compressed. In an exemplary embodiment, at least a portion of the sleeve is comprised of a frangible material. In an exemplary embodiment, the wall thickness of the sleeve is variable. In an exemplary embodiment, the predetermined portion of the apparatus has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the predetermined portion of the apparatus has a higher ductility prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the predetermined portion of the apparatus has a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the predetermined portion of the apparatus has a larger inside diameter after the radial expansion and plastic deformation than other portions of the tubular assembly. In an exemplary embodiment, the sleeve is circumferentially tensioned; and wherein the first and second tubular members are circumferentially compressed. In an exemplary embodiment, the sleeve is circumferentially tensioned; and wherein the first and second tubular members are circumferentially compressed. In an exemplary embodiment, the apparatus further includes positioning another apparatus within the preexisting structure in overlapping relation to the apparatus; and radially expanding and plastically deforming the other apparatus within the preexisting structure; wherein, prior to the radial expansion and plastic deformation of the apparatus, a predetermined portion of the other apparatus has a lower yield point than another portion of the other apparatus. In an exemplary embodiment, the inside diameter of the radially expanded and plastically deformed other portion of the apparatus is equal to the inside diameter of the radially expanded and plastically deformed other portion of the other apparatus. In an exemplary embodiment, the predetermined portion of the apparatus comprises an end portion of the

apparatus. In an exemplary embodiment, the predetermined portion of the apparatus comprises a plurality of predetermined portions of the apparatus. In an exemplary embodiment, the predetermined portion of the apparatus comprises a plurality of spaced apart predetermined portions of the apparatus. In an exemplary embodiment, the other portion of the apparatus comprises an end portion of the apparatus. In an exemplary embodiment, the other portion of the apparatus comprises a plurality of other portions of the apparatus. In an exemplary embodiment, the other portion of the apparatus comprises a plurality of spaced apart other portions of the apparatus. In an exemplary embodiment, the apparatus comprises a plurality of tubular members coupled to one another by corresponding tubular couplings. In an exemplary embodiment, the tubular couplings comprise the predetermined portions of the apparatus; and wherein the tubular members comprise the other portion of the apparatus. In an exemplary embodiment, one or more of the tubular couplings comprise the predetermined portions of the apparatus. In an exemplary embodiment, one or more of the tubular members comprise the predetermined portions of the apparatus. In an exemplary embodiment, the predetermined portion of the apparatus defines one or more openings. In an exemplary embodiment, one or more of the openings comprise slots. In an exemplary embodiment, the anisotropy for the predetermined portion of the apparatus is greater than 1. In an exemplary embodiment, the anisotropy for the predetermined portion of the apparatus is greater than 1. In an exemplary embodiment, the strain hardening exponent for the predetermined portion of the apparatus is greater than 0.12. In an exemplary embodiment, the anisotropy for the predetermined portion of the apparatus is greater than 1; and wherein the strain hardening exponent for the predetermined portion of the apparatus is greater than 0.12. In an exemplary embodiment, the predetermined portion of the apparatus comprises a first steel alloy comprising: 0.065 % C, 1.44 % Mn, 0.01 % P, 0.002 % S, 0.24 % Si, 0.01 % Cu, 0.01 % Ni, and 0.02 % Cr. In an exemplary embodiment, the yield point of the predetermined portion of the apparatus is at most about 46.9 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the apparatus is at least about 65.9 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the apparatus after the radial expansion and plastic deformation is at least about 40 % greater than the yield point of the predetermined portion of the apparatus prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the apparatus, prior to the radial expansion and plastic deformation, is about 1.48. In an exemplary embodiment, the predetermined portion of the apparatus comprises a second steel alloy comprising: 0.18 % C, 1.28 % Mn, 0.017 % P, 0.004 % S, 0.29 % Si, 0.01 % Cu, 0.01 % Ni, and 0.03 % Cr. In an exemplary embodiment, the yield point of the predetermined portion of the apparatus is at most about 57.8 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the apparatus is at least about 74.4 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the apparatus after the radial expansion and plastic deformation is at least about 28 % greater than the yield point of the predetermined portion of the apparatus prior to the radial

expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the apparatus, prior to the radial expansion and plastic deformation, is about 1.04. In an exemplary embodiment, the predetermined portion of the apparatus comprises a third steel alloy comprising: 0.08 % C, 0.82 % Mn, 0.006 % P, 0.003 % S, 0.30 % Si, 0.16 % Cu, 0.05 % Ni, and 0.05 % Cr. In an exemplary embodiment, the anisotropy of the predetermined portion of the apparatus, prior to the radial expansion and plastic deformation, is about 1.92. In an exemplary embodiment, the predetermined portion of the apparatus comprises a fourth steel alloy comprising: 0.02 % C, 1.31 % Mn, 0.02 % P, 0.001 % S, 0.45 % Si, 9.1 % Ni, and 18.7 % Cr. In an exemplary embodiment, the anisotropy of the predetermined portion of the apparatus, prior to the radial expansion and plastic deformation, is about 1.34. In an exemplary embodiment, the yield point of the predetermined portion of the apparatus is at most about 46.9 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the apparatus is at least about 65.9 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the apparatus after the radial expansion and plastic deformation is at least about 40 % greater than the yield point of the predetermined portion of the apparatus prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the apparatus, prior to the radial expansion and plastic deformation, is at least about 1.48. In an exemplary embodiment, the yield point of the predetermined portion of the apparatus is at most about 57.8 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the apparatus is at least about 74.4 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the apparatus after the radial expansion and plastic deformation is at least about 28 % greater than the yield point of the predetermined portion of the apparatus prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the apparatus, prior to the radial expansion and plastic deformation, is at least about 1.04. In an exemplary embodiment, the anisotropy of the predetermined portion of the apparatus, prior to the radial expansion and plastic deformation, is at least about 1.92. In an exemplary embodiment, the anisotropy of the predetermined portion of the apparatus, prior to the radial expansion and plastic deformation, is at least about 1.34. In an exemplary embodiment, the anisotropy of the predetermined portion of the apparatus, prior to the radial expansion and plastic deformation, ranges from about 1.04 to about 1.92. In an exemplary embodiment, the yield point of the predetermined portion of the apparatus, prior to the radial expansion and plastic deformation, ranges from about 47.6 ksi to about 61.7 ksi. In an exemplary embodiment, the expandability coefficient of the predetermined portion of the apparatus, prior to the radial expansion and plastic deformation, is greater than 0.12. In an exemplary embodiment, the expandability coefficient of the predetermined portion of the apparatus is greater than the expandability coefficient of the other portion of the apparatus. In an exemplary embodiment, the apparatus comprises a wellbore casing. In an exemplary embodiment, the

apparatus comprises a pipeline. In an exemplary embodiment, the apparatus comprises a structural support.

[000584] A radially expandable tubular member apparatus has been described that includes a first tubular member; a second tubular member engaged with the first tubular member forming a joint; a sleeve overlapping and coupling the first and second tubular members at the joint; the sleeve having opposite tapered ends and a flange engaged in a recess formed in an adjacent tubular member; and one of the tapered ends being a surface formed on the flange; wherein, prior to a radial expansion and plastic deformation of the apparatus, a predetermined portion of the apparatus has a lower yield point than another portion of the apparatus. In an exemplary embodiment, the recess includes a tapered wall in mating engagement with the tapered end formed on the flange. In an exemplary embodiment, the sleeve includes a flange at each tapered end and each tapered end is formed on a respective flange. In an exemplary embodiment, each tubular member includes a recess. In an exemplary embodiment, each flange is engaged in a respective one of the recesses. In an exemplary embodiment, each recess includes a tapered wall in mating engagement with the tapered end formed on a respective one of the flanges. In an exemplary embodiment, the predetermined portion of the apparatus has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the predetermined portion of the apparatus has a higher ductility prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the predetermined portion of the apparatus has a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the predetermined portion of the apparatus has a larger inside diameter after the radial expansion and plastic deformation than other portions of the tubular assembly. In an exemplary embodiment, the apparatus further includes positioning another apparatus within the preexisting structure in overlapping relation to the apparatus; and radially expanding and plastically deforming the other apparatus within the preexisting structure; wherein, prior to the radial expansion and plastic deformation of the apparatus, a predetermined portion of the other apparatus has a lower yield point than another portion of the other apparatus. In an exemplary embodiment, the inside diameter of the radially expanded and plastically deformed other portion of the apparatus is equal to the inside diameter of the radially expanded and plastically deformed other portion of the other apparatus. In an exemplary embodiment, the predetermined portion of the apparatus comprises an end portion of the apparatus. In an exemplary embodiment, the predetermined portion of the apparatus comprises a plurality of predetermined portions of the apparatus. In an exemplary embodiment, the predetermined portion of the apparatus comprises a plurality of spaced apart predetermined portions of the apparatus. In an exemplary embodiment, the other portion of the apparatus comprises an end portion of the apparatus. In an exemplary embodiment, the other portion of the apparatus comprises a plurality of other portions of the apparatus. In an exemplary embodiment, the other portion of the apparatus comprises a plurality of spaced apart other portions of the apparatus. In an exemplary embodiment, the apparatus comprises a

plurality of tubular members coupled to one another by corresponding tubular couplings. In an exemplary embodiment, the tubular couplings comprise the predetermined portions of the apparatus; and wherein the tubular members comprise the other portion of the apparatus. In an exemplary embodiment, one or more of the tubular couplings comprise the predetermined portions of the apparatus. In an exemplary embodiment, one or more of the tubular members comprise the predetermined portions of the apparatus. In an exemplary embodiment, the predetermined portion of the apparatus defines one or more openings. In an exemplary embodiment, one or more of the openings comprise slots. In an exemplary embodiment, the anisotropy for the predetermined portion of the apparatus is greater than 1. In an exemplary embodiment, the anisotropy for the predetermined portion of the apparatus is greater than 1. In an exemplary embodiment, the strain hardening exponent for the predetermined portion of the apparatus is greater than 0.12. In an exemplary embodiment, the anisotropy for the predetermined portion of the apparatus is greater than 1; and wherein the strain hardening exponent for the predetermined portion of the apparatus is greater than 0.12. In an exemplary embodiment, the predetermined portion of the apparatus comprises a first steel alloy comprising: 0.065 % C, 1.44 % Mn, 0.01 % P, 0.002 % S, 0.24 % Si, 0.01 % Cu, 0.01 % Ni, and 0.02 % Cr. In an exemplary embodiment, the yield point of the predetermined portion of the apparatus is at most about 46.9 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the apparatus is at least about 65.9 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the apparatus after the radial expansion and plastic deformation is at least about 40 % greater than the yield point of the predetermined portion of the apparatus prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the apparatus, prior to the radial expansion and plastic deformation, is about 1.48. In an exemplary embodiment, the predetermined portion of the apparatus comprises a second steel alloy comprising: 0.18 % C, 1.28 % Mn, 0.017 % P, 0.004 % S, 0.29 % Si, 0.01 % Cu, 0.01 % Ni, and 0.03 % Cr. In an exemplary embodiment, the yield point of the predetermined portion of the apparatus is at most about 57.8 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the apparatus is at least about 74.4 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the apparatus after the radial expansion and plastic deformation is at least about 28 % greater than the yield point of the predetermined portion of the apparatus prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the apparatus, prior to the radial expansion and plastic deformation, is about 1.04. In an exemplary embodiment, the predetermined portion of the apparatus comprises a third steel alloy comprising: 0.08 % C, 0.82 % Mn, 0.006 % P, 0.003 % S, 0.30 % Si, 0.16 % Cu, 0.05 % Ni, and 0.05 % Cr. In an exemplary embodiment, the anisotropy of the predetermined portion of the apparatus, prior to the radial expansion and plastic deformation, is about 1.92. In an exemplary embodiment, the predetermined portion of the apparatus comprises a fourth steel alloy comprising: 0.02 % C, 1.31 % Mn,

0.02 % P, 0.001 % S, 0.45 % Si, 9.1 % Ni, and 18.7 % Cr. In an exemplary embodiment, the anisotropy of the predetermined portion of the apparatus, prior to the radial expansion and plastic deformation, is about 1.34. In an exemplary embodiment, the yield point of the predetermined portion of the apparatus is at most about 46.9 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the apparatus is at least about 65.9 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the apparatus after the radial expansion and plastic deformation is at least about 40 % greater than the yield point of the predetermined portion of the apparatus prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the apparatus, prior to the radial expansion and plastic deformation, is at least about 1.48. In an exemplary embodiment, the yield point of the predetermined portion of the apparatus is at most about 57.8 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the apparatus is at least about 74.4 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the apparatus after the radial expansion and plastic deformation is at least about 28 % greater than the yield point of the predetermined portion of the apparatus prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the apparatus, prior to the radial expansion and plastic deformation, is at least about 1.04. In an exemplary embodiment, the anisotropy of the predetermined portion of the apparatus, prior to the radial expansion and plastic deformation, is at least about 1.92. In an exemplary embodiment, the anisotropy of the predetermined portion of the apparatus, prior to the radial expansion and plastic deformation, is at least about 1.34. In an exemplary embodiment, the anisotropy of the predetermined portion of the apparatus, prior to the radial expansion and plastic deformation, ranges from about 1.04 to about 1.92. In an exemplary embodiment, the yield point of the predetermined portion of the apparatus, prior to the radial expansion and plastic deformation, ranges from about 47.6 ksi to about 61.7 ksi. In an exemplary embodiment, the expandability coefficient of the predetermined portion of the apparatus, prior to the radial expansion and plastic deformation, is greater than 0.12. In an exemplary embodiment, the expandability coefficient of the predetermined portion of the apparatus is greater than the expandability coefficient of the other portion of the apparatus. In an exemplary embodiment, the apparatus comprises a wellbore casing. In an exemplary embodiment, the apparatus comprises a pipeline. In an exemplary embodiment, the apparatus comprises a structural support.

[000585] A method of joining radially expandable tubular members is provided that includes: providing a first tubular member; engaging a second tubular member with the first tubular member to form a joint; providing a sleeve; mounting the sleeve for overlapping and coupling the first and second tubular members at the joint; wherein the first tubular member, the second tubular member, and the sleeve define a tubular assembly; and radially expanding and plastically deforming the tubular assembly; wherein, prior to the radial expansion and plastic deformation, a predetermined portion of the tubular

assembly has a lower yield point than another portion of the tubular assembly. In an exemplary embodiment, the carbon content of the predetermined portion of the tubular assembly is less than or equal to 0.12 percent; and wherein the carbon equivalent value for the predetermined portion of the tubular assembly is less than 0.21. In an exemplary embodiment, the carbon content of the predetermined portion of the tubular assembly is greater than 0.12 percent; and wherein the carbon equivalent value for the predetermined portion of the tubular assembly is less than 0.36. In an exemplary embodiment, the method further includes: maintaining portions of the first and second tubular member in circumferential compression following a radial expansion and plastic deformation of the first and second tubular members. In an exemplary embodiment, the method further includes: concentrating stresses within the joint during a radial expansion and plastic deformation of the first and second tubular members. In an exemplary embodiment, the method further includes: maintaining portions of the first and second tubular member in circumferential compression following a radial expansion and plastic deformation of the first and second tubular members; and concentrating stresses within the joint during a radial expansion and plastic deformation of the first and second tubular members. In an exemplary embodiment, the method further includes: concentrating stresses within the joint. In an exemplary embodiment, concentrating stresses within the joint comprises using the first tubular member to concentrate stresses within the joint. In an exemplary embodiment, concentrating stresses within the joint comprises using the second tubular member to concentrate stresses within the joint. In an exemplary embodiment, concentrating stresses within the joint comprises using the sleeve to concentrate stresses within the joint. In an exemplary embodiment, concentrating stresses within the joint comprises using the first tubular member and the second tubular member to concentrate stresses within the joint. In an exemplary embodiment, concentrating stresses within the joint comprises using the first tubular member and the sleeve to concentrate stresses within the joint. In an exemplary embodiment, concentrating stresses within the joint comprises using the second tubular member and the sleeve to concentrate stresses within the joint. In an exemplary embodiment, concentrating stresses within the joint comprises using the first tubular member, the second tubular member, and the sleeve to concentrate stresses within the joint. In an exemplary embodiment, at least a portion of the sleeve is comprised of a frangible material. In an exemplary embodiment, the sleeve comprises a variable wall thickness. In an exemplary embodiment, the method further includes maintaining the sleeve in circumferential tension; and maintaining the first and second tubular members in circumferential compression. In an exemplary embodiment, the method further includes maintaining the sleeve in circumferential tension; and maintaining the first and second tubular members in circumferential compression. In an exemplary embodiment, the method further includes: maintaining the sleeve in circumferential tension; and maintaining the first and second tubular members in circumferential compression. In an exemplary embodiment, the method further includes: threadably coupling the first and second tubular members at a first location; threadably coupling the first and second tubular members at a second location spaced apart from the first location; providing a plurality of sleeves; and mounting the sleeves at spaced apart

locations for overlapping and coupling the first and second tubular members. In an exemplary embodiment, at least one of the tubular sleeves is positioned in opposing relation to the first threaded coupling; and wherein at least one of the tubular sleeves is positioned in opposing relation to the second threaded coupling. In an exemplary embodiment, at least one of the tubular sleeves is not positioned in opposing relation to the first and second threaded couplings. In an exemplary embodiment, the method further includes: threadably coupling the first and second tubular members; and upsetting the threaded coupling. In an exemplary embodiment, the first tubular member further comprises an annular extension extending therefrom; and wherein the flange of the sleeve defines an annular recess for receiving and mating with the annular extension of the first tubular member. In an exemplary embodiment, the predetermined portion of the tubular assembly has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the predetermined portion of the tubular assembly has a higher ductility prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the predetermined portion of the tubular assembly has a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the predetermined portion of the tubular assembly has a larger inside diameter after the radial expansion and plastic deformation than the other portion of the tubular assembly. In an exemplary embodiment, the method further includes: positioning another tubular assembly within the preexisting structure in overlapping relation to the tubular assembly; and radially expanding and plastically deforming the other tubular assembly within the preexisting structure; wherein, prior to the radial expansion and plastic deformation of the tubular assembly, a predetermined portion of the other tubular assembly has a lower yield point than another portion of the other tubular assembly. In an exemplary embodiment, the inside diameter of the radially expanded and plastically deformed other portion of the tubular assembly is equal to the inside diameter of the radially expanded and plastically deformed other portion of the other tubular assembly. In an exemplary embodiment, the predetermined portion of the tubular assembly comprises an end portion of the tubular assembly. In an exemplary embodiment, the predetermined portion of the tubular assembly comprises a plurality of predetermined portions of the tubular assembly. In an exemplary embodiment, the predetermined portion of the tubular assembly comprises a plurality of spaced apart predetermined portions of the tubular assembly. In an exemplary embodiment, the other portion of the tubular assembly comprises an end portion of the tubular assembly. In an exemplary embodiment, the other portion of the tubular assembly comprises a plurality of other portions of the tubular assembly. In an exemplary embodiment, the other portion of the tubular assembly comprises a plurality of spaced apart other portions of the tubular assembly. In an exemplary embodiment, the tubular assembly comprises a plurality of tubular members coupled to one another by corresponding tubular couplings. In an exemplary embodiment, the tubular couplings comprise the predetermined portions of the tubular assembly; and wherein the tubular members comprise the other portion of the tubular assembly. In an exemplary embodiment, one or more of the tubular couplings

comprise the predetermined portions of the tubular assembly. In an exemplary embodiment, one or more of the tubular members comprise the predetermined portions of the tubular assembly. In an exemplary embodiment, the predetermined portion of the tubular assembly defines one or more openings. In an exemplary embodiment, one or more of the openings comprise slots. In an exemplary embodiment, the anisotropy for the predetermined portion of the tubular assembly is greater than 1. In an exemplary embodiment, the anisotropy for the predetermined portion of the tubular assembly is greater than 1. In an exemplary embodiment, the strain hardening exponent for the predetermined portion of the tubular assembly is greater than 0.12. In an exemplary embodiment, the anisotropy for the predetermined portion of the tubular assembly is greater than 1; and wherein the strain hardening exponent for the predetermined portion of the tubular assembly is greater than 0.12. In an exemplary embodiment, the predetermined portion of the tubular assembly comprises a first steel alloy comprising: 0.065 % C, 1.44 % Mn, 0.01 % P, 0.002 % S, 0.24 % Si, 0.01 % Cu, 0.01 % Ni, and 0.02 % Cr. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly is at most about 46.9 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the tubular assembly is at least about 65.9 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly after the radial expansion and plastic deformation is at least about 40 % greater than the yield point of the predetermined portion of the tubular assembly prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is about 1.48. In an exemplary embodiment, the predetermined portion of the tubular assembly comprises a second steel alloy comprising: 0.18 % C, 1.28 % Mn, 0.017 % P, 0.004 % S, 0.29 % Si, 0.01 % Cu, 0.01 % Ni, and 0.03 % Cr. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly is at most about 57.8 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the tubular assembly is at least about 74.4 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly after the radial expansion and plastic deformation is at least about 28 % greater than the yield point of the predetermined portion of the tubular assembly prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is about 1.04. In an exemplary embodiment, the predetermined portion of the tubular assembly comprises a third steel alloy comprising: 0.08 % C, 0.82 % Mn, 0.006 % P, 0.003 % S, 0.30 % Si, 0.16 % Cu, 0.05 % Ni, and 0.05 % Cr. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is about 1.92. In an exemplary embodiment, the predetermined portion of the tubular assembly comprises a fourth steel alloy comprising: 0.02 % C, 1.31 % Mn, 0.02 % P, 0.001 % S, 0.45 % Si, 9.1 % Ni, and 18.7 % Cr. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is

about 1.34. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly is at most about 46.9 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the tubular assembly is at least about 65.9 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly after the radial expansion and plastic deformation is at least about 40 % greater than the yield point of the predetermined portion of the tubular assembly prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is at least about 1.48. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly is at most about 57.8 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the tubular assembly is at least about 74.4 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly after the radial expansion and plastic deformation is at least about 28 % greater than the yield point of the predetermined portion of the tubular assembly prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is at least about 1.04. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is at least about 1.92. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is at least about 1.34. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, ranges from about 1.04 to about 1.92. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, ranges from about 47.6 ksi to about 61.7 ksi. In an exemplary embodiment, the expandability coefficient of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is greater than 0.12. In an exemplary embodiment, the expandability coefficient of the predetermined portion of the tubular assembly is greater than the expandability coefficient of the other portion of the tubular assembly. In an exemplary embodiment, the tubular assembly comprises a wellbore casing. In an exemplary embodiment, the tubular assembly comprises a pipeline. In an exemplary embodiment, the tubular assembly comprises a structural support.

[000586] A method of joining radially expandable tubular members has been described that includes: providing a first tubular member; engaging a second tubular member with the first tubular member to form a joint; providing a sleeve having opposite tapered ends and a flange, one of the tapered ends being a surface formed on the flange; mounting the sleeve for overlapping and coupling the first and second tubular members at the joint, wherein the flange is engaged in a recess formed in an adjacent one of the tubular members; wherein the first tubular member, the second tubular member, and the sleeve define a tubular assembly; and radially expanding and plastically deforming the tubular assembly;

wherein, prior to the radial expansion and plastic deformation, a predetermined portion of the tubular assembly has a lower yield point than another portion of the tubular assembly. In an exemplary embodiment, the method further includes: providing a tapered wall in the recess for mating engagement with the tapered end formed on the flange. In an exemplary embodiment, the method further includes: providing a flange at each tapered end wherein each tapered end is formed on a respective flange. In an exemplary embodiment, the method further includes: providing a recess in each tubular member. In an exemplary embodiment, the method further includes: engaging each flange in a respective one of the recesses. In an exemplary embodiment, the method further includes: providing a tapered wall in each recess for mating engagement with the tapered end formed on a respective one of the flanges. In an exemplary embodiment, the predetermined portion of the tubular assembly has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the predetermined portion of the tubular assembly has a higher ductility prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the predetermined portion of the tubular assembly has a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the predetermined portion of the tubular assembly has a larger inside diameter after the radial expansion and plastic deformation than the other portion of the tubular assembly. In an exemplary embodiment, the method further includes: positioning another tubular assembly within the preexisting structure in overlapping relation to the tubular assembly; and radially expanding and plastically deforming the other tubular assembly within the preexisting structure; wherein, prior to the radial expansion and plastic deformation of the tubular assembly, a predetermined portion of the other tubular assembly has a lower yield point than another portion of the other tubular assembly. In an exemplary embodiment, the inside diameter of the radially expanded and plastically deformed other portion of the tubular assembly is equal to the inside diameter of the radially expanded and plastically deformed other portion of the other tubular assembly. In an exemplary embodiment, the predetermined portion of the tubular assembly comprises an end portion of the tubular assembly. In an exemplary embodiment, the predetermined portion of the tubular assembly comprises a plurality of predetermined portions of the tubular assembly. In an exemplary embodiment, the predetermined portion of the tubular assembly comprises a plurality of spaced apart predetermined portions of the tubular assembly. In an exemplary embodiment, the other portion of the tubular assembly comprises an end portion of the tubular assembly. In an exemplary embodiment, the other portion of the tubular assembly comprises a plurality of other portions of the tubular assembly. In an exemplary embodiment, the other portion of the tubular assembly comprises a plurality of spaced apart other portions of the tubular assembly. In an exemplary embodiment, the tubular assembly comprises a plurality of tubular members coupled to one another by corresponding tubular couplings. In an exemplary embodiment, the tubular couplings comprise the predetermined portions of the tubular assembly; and wherein the tubular members comprise the other portion of the tubular assembly. In an

exemplary embodiment, one or more of the tubular couplings comprise the predetermined portions of the tubular assembly. In an exemplary embodiment, one or more of the tubular members comprise the predetermined portions of the tubular assembly. In an exemplary embodiment, the predetermined portion of the tubular assembly defines one or more openings. In an exemplary embodiment, one or more of the openings comprise slots. In an exemplary embodiment, the anisotropy for the predetermined portion of the tubular assembly is greater than 1. In an exemplary embodiment, the anisotropy for the predetermined portion of the tubular assembly is greater than 1. In an exemplary embodiment, the strain hardening exponent for the predetermined portion of the tubular assembly is greater than 0.12. In an exemplary embodiment, the anisotropy for the predetermined portion of the tubular assembly is greater than 1; and wherein the strain hardening exponent for the predetermined portion of the tubular assembly is greater than 0.12. In an exemplary embodiment, the predetermined portion of the tubular assembly comprises a first steel alloy comprising: 0.065 % C, 1.44 % Mn, 0.01 % P, 0.002 % S, 0.24 % Si, 0.01 % Cu, 0.01 % Ni, and 0.02 % Cr. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly is at most about 46.9 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the tubular assembly is at least about 65.9 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly after the radial expansion and plastic deformation is at least about 40 % greater than the yield point of the predetermined portion of the tubular assembly prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is about 1.48. In an exemplary embodiment, the predetermined portion of the tubular assembly comprises a second steel alloy comprising: 0.18 % C, 1.28 % Mn, 0.017 % P, 0.004 % S, 0.29 % Si, 0.01 % Cu, 0.01 % Ni, and 0.03 % Cr. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly is at most about 57.8 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the tubular assembly is at least about 74.4 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly after the radial expansion and plastic deformation is at least about 28 % greater than the yield point of the predetermined portion of the tubular assembly prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is about 1.04. In an exemplary embodiment, the predetermined portion of the tubular assembly comprises a third steel alloy comprising: 0.08 % C, 0.82 % Mn, 0.006 % P, 0.003 % S, 0.30 % Si, 0.16 % Cu, 0.05 % Ni, and 0.05 % Cr. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is about 1.92. In an exemplary embodiment, the predetermined portion of the tubular assembly comprises a fourth steel alloy comprising: 0.02 % C, 1.31 % Mn, 0.02 % P, 0.001 % S, 0.45 % Si, 9.1 % Ni, and 18.7 % Cr. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly,

prior to the radial expansion and plastic deformation, is about 1.34. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly is at most about 46.9 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the tubular assembly is at least about 65.9 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly after the radial expansion and plastic deformation is at least about 40 % greater than the yield point of the predetermined portion of the tubular assembly prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is at least about 1.48. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly is at most about 57.8 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the tubular assembly is at least about 74.4 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly after the radial expansion and plastic deformation is at least about 28 % greater than the yield point of the predetermined portion of the tubular assembly prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is at least about 1.04. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is at least about 1.92. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is at least about 1.34. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, ranges from about 1.04 to about 1.92. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, ranges from about 47.6 ksi to about 61.7 ksi. In an exemplary embodiment, the expandability coefficient of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is greater than 0.12. In an exemplary embodiment, the expandability coefficient of the predetermined portion of the tubular assembly is greater than the expandability coefficient of the other portion of the tubular assembly. In an exemplary embodiment, the tubular assembly comprises a wellbore casing. In an exemplary embodiment, the tubular assembly comprises a pipeline. In an exemplary embodiment, the tubular assembly comprises a structural support.

[000587] An expandable tubular assembly has been described that includes a first tubular member; a second tubular member coupled to the first tubular member; a first threaded connection for coupling a portion of the first and second tubular members; a second threaded connection spaced apart from the first threaded connection for coupling another portion of the first and second tubular members; a tubular sleeve coupled to and receiving end portions of the first and second tubular members; and a sealing element positioned between the first and second spaced apart threaded connections for sealing an interface between the first and second tubular member; wherein the sealing element is positioned within

an annulus defined between the first and second tubular members; and wherein, prior to a radial expansion and plastic deformation of the assembly, a predetermined portion of the assembly has a lower yield point than another portion of the apparatus. In an exemplary embodiment, the predetermined portion of the assembly has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the predetermined portion of the assembly has a higher ductility prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the predetermined portion of the assembly has a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the predetermined portion of the assembly has a larger inside diameter after the radial expansion and plastic deformation than other portions of the tubular assembly. In an exemplary embodiment, the assembly further includes: positioning another assembly within the preexisting structure in overlapping relation to the assembly; and radially expanding and plastically deforming the other assembly within the preexisting structure; wherein, prior to the radial expansion and plastic deformation of the assembly, a predetermined portion of the other assembly has a lower yield point than another portion of the other assembly. In an exemplary embodiment, the inside diameter of the radially expanded and plastically deformed other portion of the assembly is equal to the inside diameter of the radially expanded and plastically deformed other portion of the other assembly. In an exemplary embodiment, the predetermined portion of the assembly comprises an end portion of the assembly. In an exemplary embodiment, the predetermined portion of the assembly comprises a plurality of predetermined portions of the assembly. In an exemplary embodiment, the predetermined portion of the assembly comprises a plurality of spaced apart predetermined portions of the assembly. In an exemplary embodiment, the other portion of the assembly comprises an end portion of the assembly. In an exemplary embodiment, the other portion of the assembly comprises a plurality of other portions of the assembly. In an exemplary embodiment, the other portion of the assembly comprises a plurality of spaced apart other portions of the assembly. In an exemplary embodiment, the assembly comprises a plurality of tubular members coupled to one another by corresponding tubular couplings. In an exemplary embodiment, the tubular couplings comprise the predetermined portions of the assembly; and wherein the tubular members comprise the other portion of the assembly. In an exemplary embodiment, one or more of the tubular couplings comprise the predetermined portions of the assembly. In an exemplary embodiment, one or more of the tubular members comprise the predetermined portions of the assembly. In an exemplary embodiment, the predetermined portion of the assembly defines one or more openings. In an exemplary embodiment, one or more of the openings comprise slots. In an exemplary embodiment, the anisotropy for the predetermined portion of the assembly is greater than 1. In an exemplary embodiment, the anisotropy for the predetermined portion of the assembly is greater than 1. In an exemplary embodiment, the strain hardening exponent for the predetermined portion of the assembly is greater than 0.12. In an exemplary embodiment, the anisotropy for the predetermined portion of the assembly is greater than 1; and wherein

the strain hardening exponent for the predetermined portion of the assembly is greater than 0.12. In an exemplary embodiment, the predetermined portion of the assembly comprises a first steel alloy comprising: 0.065 % C, 1.44 % Mn, 0.01 % P, 0.002 % S, 0.24 % Si, 0.01 % Cu, 0.01 % Ni, and 0.02 % Cr. In an exemplary embodiment, the yield point of the predetermined portion of the assembly is at most about 46.9 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the assembly is at least about 65.9 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the assembly after the radial expansion and plastic deformation is at least about 40 % greater than the yield point of the predetermined portion of the assembly prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the assembly, prior to the radial expansion and plastic deformation, is about 1.48. In an exemplary embodiment, the predetermined portion of the assembly comprises a second steel alloy comprising: 0.18 % C, 1.28 % Mn, 0.017 % P, 0.004 % S, 0.29 % Si, 0.01 % Cu, 0.01 % Ni, and 0.03 % Cr. In an exemplary embodiment, the yield point of the predetermined portion of the assembly is at most about 57.8 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the assembly is at least about 74.4 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the assembly after the radial expansion and plastic deformation is at least about 28 % greater than the yield point of the predetermined portion of the assembly prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the assembly, prior to the radial expansion and plastic deformation, is about 1.04. In an exemplary embodiment, the predetermined portion of the assembly comprises a third steel alloy comprising: 0.08 % C, 0.82 % Mn, 0.006 % P, 0.003 % S, 0.30 % Si, 0.16 % Cu, 0.05 % Ni, and 0.05 % Cr. In an exemplary embodiment, the anisotropy of the predetermined portion of the assembly, prior to the radial expansion and plastic deformation, is about 1.92. In an exemplary embodiment, the predetermined portion of the assembly comprises a fourth steel alloy comprising: 0.02 % C, 1.31 % Mn, 0.02 % P, 0.001 % S, 0.45 % Si, 9.1 % Ni, and 18.7 % Cr. In an exemplary embodiment, the anisotropy of the predetermined portion of the assembly, prior to the radial expansion and plastic deformation, is about 1.34. In an exemplary embodiment, the yield point of the predetermined portion of the assembly is at most about 46.9 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the assembly is at least about 65.9 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the assembly after the radial expansion and plastic deformation is at least about 40 % greater than the yield point of the predetermined portion of the assembly prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the assembly, prior to the radial expansion and plastic deformation, is at least about 1.48. In an exemplary embodiment, the yield point of the predetermined portion of the assembly is at most about 57.8 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the

predetermined portion of the assembly is at least about 74.4 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the assembly after the radial expansion and plastic deformation is at least about 28 % greater than the yield point of the predetermined portion of the assembly prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the assembly, prior to the radial expansion and plastic deformation, is at least about 1.04. In an exemplary embodiment, the anisotropy of the predetermined portion of the assembly, prior to the radial expansion and plastic deformation, is at least about 1.92. In an exemplary embodiment, the anisotropy of the predetermined portion of the assembly, prior to the radial expansion and plastic deformation, is at least about 1.34. In an exemplary embodiment, the anisotropy of the predetermined portion of the assembly, prior to the radial expansion and plastic deformation, ranges from about 1.04 to about 1.92. In an exemplary embodiment, the yield point of the predetermined portion of the assembly, prior to the radial expansion and plastic deformation, ranges from about 47.6 ksi to about 61.7 ksi. In an exemplary embodiment, the expandability coefficient of the predetermined portion of the assembly, prior to the radial expansion and plastic deformation, is greater than 0.12. In an exemplary embodiment, the expandability coefficient of the predetermined portion of the assembly is greater than the expandability coefficient of the other portion of the assembly. In an exemplary embodiment, the assembly comprises a wellbore casing. In an exemplary embodiment, the assembly comprises a pipeline. In an exemplary embodiment, the assembly comprises a structural support. In an exemplary embodiment, the annulus is at least partially defined by an irregular surface. In an exemplary embodiment, the annulus is at least partially defined by a toothed surface. In an exemplary embodiment, the sealing element comprises an elastomeric material. In an exemplary embodiment, the sealing element comprises a metallic material. In an exemplary embodiment, the sealing element comprises an elastomeric and a metallic material.

[000588] A method of joining radially expandable tubular members is provided that includes providing a first tubular member; providing a second tubular member; providing a sleeve; mounting the sleeve for overlapping and coupling the first and second tubular members; threadably coupling the first and second tubular members at a first location; threadably coupling the first and second tubular members at a second location spaced apart from the first location; sealing an interface between the first and second tubular members between the first and second locations using a compressible sealing element, wherein the first tubular member, second tubular member, sleeve, and the sealing element define a tubular assembly; and radially expanding and plastically deforming the tubular assembly; wherein, prior to the radial expansion and plastic deformation, a predetermined portion of the tubular assembly has a lower yield point than another portion of the tubular assembly. In an exemplary embodiment, the sealing element includes an irregular surface. In an exemplary embodiment, the sealing element includes a toothed surface. In an exemplary embodiment, the sealing element comprises an elastomeric material. In an exemplary embodiment, the sealing element comprises a metallic material. In an exemplary embodiment, the sealing element comprises an elastomeric and a metallic material. In an exemplary

embodiment, the predetermined portion of the tubular assembly has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the predetermined portion of the tubular assembly has a higher ductility prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the predetermined portion of the tubular assembly has a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the predetermined portion of the tubular assembly has a larger inside diameter after the radial expansion and plastic deformation than the other portion of the tubular assembly. In an exemplary embodiment, the method further includes: positioning another tubular assembly within the preexisting structure in overlapping relation to the tubular assembly; and radially expanding and plastically deforming the other tubular assembly within the preexisting structure; wherein, prior to the radial expansion and plastic deformation of the tubular assembly, a predetermined portion of the other tubular assembly has a lower yield point than another portion of the other tubular assembly. In an exemplary embodiment, the inside diameter of the radially expanded and plastically deformed other portion of the tubular assembly is equal to the inside diameter of the radially expanded and plastically deformed other portion of the other tubular assembly. In an exemplary embodiment, the predetermined portion of the tubular assembly comprises an end portion of the tubular assembly. In an exemplary embodiment, the predetermined portion of the tubular assembly comprises a plurality of predetermined portions of the tubular assembly. In an exemplary embodiment, the predetermined portion of the tubular assembly comprises a plurality of spaced apart predetermined portions of the tubular assembly. In an exemplary embodiment, the other portion of the tubular assembly comprises an end portion of the tubular assembly. In an exemplary embodiment, the other portion of the tubular assembly comprises a plurality of other portions of the tubular assembly. In an exemplary embodiment, the other portion of the tubular assembly comprises a plurality of spaced apart other portions of the tubular assembly. In an exemplary embodiment, the tubular assembly comprises a plurality of tubular members coupled to one another by corresponding tubular couplings. In an exemplary embodiment, the tubular couplings comprise the predetermined portions of the tubular assembly; and wherein the tubular members comprise the other portion of the tubular assembly. In an exemplary embodiment, one or more of the tubular couplings comprise the predetermined portions of the tubular assembly. In an exemplary embodiment, one or more of the tubular members comprise the predetermined portions of the tubular assembly. In an exemplary embodiment, the predetermined portion of the tubular assembly defines one or more openings. In an exemplary embodiment, one or more of the openings comprise slots. In an exemplary embodiment, the anisotropy for the predetermined portion of the tubular assembly is greater than 1. In an exemplary embodiment, the anisotropy for the predetermined portion of the tubular assembly is greater than 1. In an exemplary embodiment, the strain hardening exponent for the predetermined portion of the tubular assembly is greater than 0.12. In an exemplary embodiment, the anisotropy for the predetermined portion of the tubular assembly is greater

than 1; and wherein the strain hardening exponent for the predetermined portion of the tubular assembly is greater than 0.12. In an exemplary embodiment, the predetermined portion of the tubular assembly comprises a first steel alloy comprising: 0.065 % C, 1.44 % Mn, 0.01 % P, 0.002 % S, 0.24 % Si, 0.01 % Cu, 0.01 % Ni, and 0.02 % Cr. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly is at most about 46.9 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the tubular assembly is at least about 65.9 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly after the radial expansion and plastic deformation is at least about 40 % greater than the yield point of the predetermined portion of the tubular assembly prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is about 1.48. In an exemplary embodiment, the predetermined portion of the tubular assembly comprises a second steel alloy comprising: 0.18 % C, 1.28 % Mn, 0.017 % P, 0.004 % S, 0.29 % Si, 0.01 % Cu, 0.01 % Ni, and 0.03 % Cr. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly is at most about 57.8 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the tubular assembly is at least about 74.4 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly after the radial expansion and plastic deformation is at least about 28 % greater than the yield point of the predetermined portion of the tubular assembly prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is about 1.04. In an exemplary embodiment, the predetermined portion of the tubular assembly comprises a third steel alloy comprising: 0.08 % C, 0.82 % Mn, 0.006 % P, 0.003 % S, 0.30 % Si, 0.16 % Cu, 0.05 % Ni, and 0.05 % Cr. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is about 1.92. In an exemplary embodiment, the predetermined portion of the tubular assembly comprises a fourth steel alloy comprising: 0.02 % C, 1.31 % Mn, 0.02 % P, 0.001 % S, 0.45 % Si, 9.1 % Ni, and 18.7 % Cr. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is about 1.34. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly is at most about 46.9 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the tubular assembly is at least about 65.9 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly after the radial expansion and plastic deformation is at least about 40 % greater than the yield point of the predetermined portion of the tubular assembly prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is at least about 1.48. In an exemplary embodiment, the

yield point of the predetermined portion of the tubular assembly is at most about 57.8 ksi prior to the radial expansion and plastic deformation; and wherein the yield point of the predetermined portion of the tubular assembly is at least about 74.4 ksi after the radial expansion and plastic deformation. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly after the radial expansion and plastic deformation is at least about 28 % greater than the yield point of the predetermined portion of the tubular assembly prior to the radial expansion and plastic deformation. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is at least about 1.04. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is at least about 1.92. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is at least about 1.34. In an exemplary embodiment, the anisotropy of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, ranges from about 1.04 to about 1.92. In an exemplary embodiment, the yield point of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, ranges from about 47.6 ksi to about 61.7 ksi. In an exemplary embodiment, the expandability coefficient of the predetermined portion of the tubular assembly, prior to the radial expansion and plastic deformation, is greater than 0.12. In an exemplary embodiment, the expandability coefficient of the predetermined portion of the tubular assembly is greater than the expandability coefficient of the other portion of the tubular assembly. In an exemplary embodiment, the tubular assembly comprises a wellbore casing. In an exemplary embodiment, the tubular assembly comprises a pipeline. In an exemplary embodiment, the tubular assembly comprises a structural support. In an exemplary embodiment, the sleeve comprises: a plurality of spaced apart tubular sleeves coupled to and receiving end portions of the first and second tubular members. In an exemplary embodiment, the first tubular member comprises a first threaded connection; wherein the second tubular member comprises a second threaded connection; wherein the first and second threaded connections are coupled to one another; wherein at least one of the tubular sleeves is positioned in opposing relation to the first threaded connection; and wherein at least one of the tubular sleeves is positioned in opposing relation to the second threaded connection. In an exemplary embodiment, the first tubular member comprises a first threaded connection; wherein the second tubular member comprises a second threaded connection; wherein the first and second threaded connections are coupled to one another; and wherein at least one of the tubular sleeves is not positioned in opposing relation to the first and second threaded connections. In an exemplary embodiment, the carbon content of the tubular member is less than or equal to 0.12 percent; and wherein the carbon equivalent value for the tubular member is less than 0.21. In an exemplary embodiment, the tubular member comprises a wellbore casing.

[000589] An expandable tubular member has been described, wherein the carbon content of the tubular member is greater than 0.12 percent; and wherein the carbon equivalent value for the tubular

member is less than 0.36. In an exemplary embodiment, the tubular member comprises a wellbore casing.

[000590] A method of selecting tubular members for radial expansion and plastic deformation has been described that includes: selecting a tubular member from a collection of tubular member; determining a carbon content of the selected tubular member; determining a carbon equivalent value for the selected tubular member; and if the carbon content of the selected tubular member is less than or equal to 0.12 percent and the carbon equivalent value for the selected tubular member is less than 0.21, then determining that the selected tubular member is suitable for radial expansion and plastic deformation.

[000591] A method of selecting tubular members for radial expansion and plastic deformation has been described that includes: selecting a tubular member from a collection of tubular member; determining a carbon content of the selected tubular member; determining a carbon equivalent value for the selected tubular member; and if the carbon content of the selected tubular member is greater than 0.12 percent and the carbon equivalent value for the selected tubular member is less than 0.36, then determining that the selected tubular member is suitable for radial expansion and plastic deformation.

[000592] An expandable tubular member has been described that includes: a tubular body; wherein a yield point of an inner tubular portion of the tubular body is less than a yield point of an outer tubular portion of the tubular body. In an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies in an linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies in an non-linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the outer tubular portion of the tubular body varies as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the outer tubular portion of the tubular body varies in an linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the outer tubular portion of the tubular body varies in an non-linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies as a function of the radial position within the tubular body; and wherein the yield point of the outer tubular portion of the tubular body varies as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies in a linear fashion as a function of the radial position within the tubular body; and wherein the yield point of the outer tubular portion of the tubular body varies in a linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies in a linear fashion as a function of the radial position within the tubular body; and wherein the yield point of the outer tubular portion of the tubular body varies in a non-linear fashion as a function of the radial position within the tubular body. In

an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies in a non-linear fashion as a function of the radial position within the tubular body; and wherein the yield point of the outer tubular portion of the tubular body varies in a linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the yield point of the inner tubular portion of the tubular body varies in a non-linear fashion as a function of the radial position within the tubular body; and wherein the yield point of the outer tubular portion of the tubular body varies in a non-linear fashion as a function of the radial position within the tubular body. In an exemplary embodiment, the rate of change of the yield point of the inner tubular portion of the tubular body is different than the rate of change of the yield point of the outer tubular portion of the tubular body. In an exemplary embodiment, the rate of change of the yield point of the inner tubular portion of the tubular body is different than the rate of change of the yield point of the outer tubular portion of the tubular body.

[000593] A method of manufacturing an expandable tubular member has been described that includes: providing a tubular member; heat treating the tubular member; and quenching the tubular member; wherein following the quenching, the tubular member comprises a microstructure comprising a hard phase structure and a soft phase structure. In an exemplary embodiment, the provided tubular member comprises, by weight percentage, 0.065% C, 1.44% Mn, 0.01% P, 0.002% S, 0.24% Si, 0.01% Cu, 0.01% Ni, 0.02% Cr, 0.05% V, 0.01% Mo, 0.01% Nb, and 0.01%Ti. In an exemplary embodiment, the provided tubular member comprises, by weight percentage, 0.18% C, 1.28% Mn, 0.017% P, 0.004% S, 0.29% Si, 0.01% Cu, 0.01% Ni, 0.03% Cr, 0.04% V, 0.01% Mo, 0.03% Nb, and 0.01%Ti. In an exemplary embodiment, the provided tubular member comprises, by weight percentage, 0.08% C, 0.82% Mn, 0.006% P, 0.003% S, 0.30% Si, 0.06% Cu, 0.05% Ni, 0.05% Cr, 0.03% V, 0.03% Mo, 0.01% Nb, and 0.01%Ti. In an exemplary embodiment, the provided tubular member comprises a microstructure comprising one or more of the following: martensite, pearlite, vanadium carbide, nickel carbide, or titanium carbide. In an exemplary embodiment, the provided tubular member comprises a microstructure comprising one or more of the following: pearlite or pearlite striation. In an exemplary embodiment, the provided tubular member comprises a microstructure comprising one or more of the following: grain pearlite, widmanstatten martensite, vanadium carbide, nickel carbide, or titanium carbide. In an exemplary embodiment, the heat treating comprises heating the provided tubular member for about 10 minutes at 790 °C. In an exemplary embodiment, the quenching comprises quenching the heat treated tubular member in water. In an exemplary embodiment, following the quenching, the tubular member comprises a microstructure comprising one or more of the following: ferrite, grain pearlite, or martensite. In an exemplary embodiment, following the quenching, the tubular member comprises a microstructure comprising one or more of the following: ferrite, martensite, or bainite. In an exemplary embodiment, following the quenching, the tubular member comprises a microstructure comprising one or more of the following: bainite, pearlite, or ferrite. In an exemplary embodiment, following the quenching, the tubular member comprises a yield strength of about 67ksi and a tensile strength of about 95 ksi. In an exemplary embodiment, following the quenching, the tubular member comprises a yield strength of about 82 ksi and

a tensile strength of about 130 ksi. In an exemplary embodiment, following the quenching, the tubular member comprises a yield strength of about 60 ksi and a tensile strength of about 97 ksi. In an exemplary embodiment, the method further includes: positioning the quenched tubular member within a preexisting structure; and radially expanding and plastically deforming the tubular member within the preexisting structure.

[000594] A method of radially expanding a tubular assembly has been described that includes radially expanding and plastically deforming a lower portion of the tubular assembly by pressurizing the interior of the lower portion of the tubular assembly; and then, radially expanding and plastically deforming the remaining portion of the tubular assembly by contacting the interior of the tubular assembly with an expansion device. In an exemplary embodiment, the expansion device is an adjustable expansion device. In an exemplary embodiment, the expansion device is a hydroforming expansion device. In an exemplary embodiment, the expansion device is a rotary expansion device. In an exemplary embodiment, the lower portion of the tubular assembly has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the remaining portion of the tubular assembly has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the lower portion of the tubular assembly includes a shoe defining a valveable passage.

[000595] A system for radially expanding a tubular assembly has been described that includes means for radially expanding and plastically deforming a lower portion of the tubular assembly by pressurizing the interior of the lower portion of the tubular assembly; and then, means for radially expanding and plastically deforming the remaining portion of the tubular assembly by contacting the interior of the tubular assembly with an expansion device. In an exemplary embodiment, the lower portion of the tubular assembly has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the remaining portion of the tubular assembly has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation.

[000596] A method of repairing a tubular assembly has been described that includes positioning a tubular patch within the tubular assembly; and radially expanding and plastically deforming a tubular patch into engagement with the tubular assembly by pressurizing the interior of the tubular patch. In an exemplary embodiment, the tubular patch has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation.

[000597] A system for repairing a tubular assembly has been described that includes means for positioning a tubular patch within the tubular assembly; and means for radially expanding and plastically deforming a tubular patch into engagement with the tubular assembly by pressurizing the interior of the tubular patch. In an exemplary embodiment, the tubular patch has a higher ductility and a lower yield

point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation.

[000598] A method of radially expanding a tubular member has been described that includes accumulating a supply of pressurized fluid; and controllably injecting the pressurized fluid into the interior of the tubular member. In an exemplary embodiment, accumulating the supply of pressurized fluid includes: monitoring the operating pressure of the accumulated fluid; and if the operating pressure of the accumulated fluid is less than a predetermined amount, injecting pressurized fluid into the accumulated fluid. In an exemplary embodiment, controllably injecting the pressurized fluid into the interior of the tubular member includes: monitoring the operating condition of the tubular member; and if the tubular member has been radial expanded, releasing the pressurized fluid from the interior of the tubular member.

[000599] A system for radially expanding a tubular member has been described that includes means for accumulating a supply of pressurized fluid; and means for controllably injecting the pressurized fluid into the interior of the tubular member. In an exemplary embodiment, means for accumulating the supply of pressurized fluid includes: means for monitoring the operating pressure of the accumulated fluid; and if the operating pressure of the accumulated fluid is less than a predetermined amount, means for injecting pressurized fluid into the accumulated fluid. In an exemplary embodiment, means for controllably injecting the pressurized fluid into the interior of the tubular member includes: means for monitoring the operating condition of the tubular member; and if the tubular member has been radial expanded, means for releasing the pressurized fluid from the interior of the tubular member.

[000600] An apparatus for radially expanding a tubular member has been described that includes a fluid reservoir; a pump for pumping fluids out of the fluid reservoir; an accumulator for receiving and accumulating the fluids pumped from the reservoir; a flow control valve for controllably releasing the fluids accumulated within the reservoir; and an expansion element for engaging the interior of the tubular member to define a pressure chamber within the tubular member and receiving the released accumulated fluids into the pressure chamber.

[000601] An apparatus for radially expanding a tubular member has been described that includes an expandable tubular member; a locking device positioned within the expandable tubular member releasably coupled to the expandable tubular member; a tubular support member positioned within the expandable tubular member coupled to the locking device; and an adjustable expansion device positioned within the expandable tubular member coupled to the tubular support member; wherein at least a portion of the expandable tubular member has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the apparatus further includes: means for transmitting torque between the expandable tubular member and the tubular support member. In an exemplary embodiment, the apparatus further includes: means for sealing the interface between the expandable tubular member and the tubular support member. In an exemplary embodiment, the apparatus further includes: another

tubular support member received within the tubular support member releasably coupled to the expandable tubular member. In an exemplary embodiment, the apparatus further includes: means for transmitting torque between the expandable tubular member and the other tubular support member. In an exemplary embodiment, the apparatus further includes: means for transmitting torque between the other tubular support member and the tubular support member. In an exemplary embodiment, the apparatus further includes: means for sealing the interface between the other tubular support member and the tubular support member. In an exemplary embodiment, the apparatus further includes: means for sealing the interface between the expandable tubular member and the tubular support member. In an exemplary embodiment, the apparatus further includes: means for sensing the operating pressure within the other tubular support member. In an exemplary embodiment, the apparatus further includes: means for pressurizing the interior of the other tubular support member. In an exemplary embodiment, further includes: means for limiting axial displacement of the other tubular support member relative to the tubular support member. In an exemplary embodiment, the apparatus further includes: a tubular liner coupled to an end of the expandable tubular member. In an exemplary embodiment, the apparatus further includes: a tubular liner coupled to an end of the expandable tubular member.

[000602] An apparatus for radially expanding a tubular member has been described that includes: an expandable tubular member; a locking device positioned within the expandable tubular member releasably coupled to the expandable tubular member; a tubular support member positioned within the expandable tubular member coupled to the locking device; an adjustable expansion device positioned within the expandable tubular member coupled to the tubular support member; means for transmitting torque between the expandable tubular member and the tubular support member; means for sealing the interface between the expandable tubular member and the tubular support member; another tubular support member received within the tubular support member releasably coupled to the expandable tubular member; means for transmitting torque between the expandable tubular member and the other tubular support member; means for transmitting torque between the other tubular support member and the tubular support member; means for sealing the interface between the other tubular support member and the tubular support member; means for sealing the interface between the expandable tubular member and the tubular support member; means for sensing the operating pressure within the other tubular support member; means for pressurizing the interior of the other tubular support member; means for limiting axial displacement of the other tubular support member relative to the tubular support member; and a tubular liner coupled to an end of the expandable tubular member; wherein at least a portion of the expandable tubular member has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation.

[000603] A method for radially expanding a tubular member has been described that includes positioning a tubular member and an adjustable expansion device within a preexisting structure; radially expanding and plastically deforming at least a portion of the tubular member by pressurizing an interior portion of the tubular member; increasing the size of the adjustable expansion device; and radially

expanding and plastically deforming another portion of the tubular member by displacing the adjustable expansion device relative to the tubular member. In an exemplary embodiment, the method further includes sensing an operating pressure within the tubular member. In an exemplary embodiment, wherein radially expanding and plastically deforming at least a portion of the tubular member by pressurizing an interior portion of the tubular member includes: injecting fluidic material into the tubular member; sensing the operating pressure of the injected fluidic material; and if the operating pressure of the injected fluidic material exceeds a predetermined value, permitting the fluidic material to enter a pressure chamber defined within the tubular member. In an exemplary embodiment, at least a portion of the tubular member has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the portion of the tubular member comprises the pressurized portion of the tubular member.

[000604] A system for radially expanding a tubular member has been described that includes means for positioning a tubular member and an adjustable expansion device within a preexisting structure; means for radially expanding and plastically deforming at least a portion of the tubular member by pressurizing an interior portion of the tubular member; means for increasing the size of the adjustable expansion device; and means for radially expanding and plastically deforming another portion of the tubular member by displacing the adjustable expansion device relative to the tubular member. In an exemplary embodiment, the system further includes: sensing an operating pressure within the tubular member. In an exemplary embodiment, radially expanding and plastically deforming at least a portion of the tubular member by pressurizing an interior portion of the tubular member includes: injecting fluidic material into the tubular member; sensing the operating pressure of the injected fluidic material; and if the operating pressure of the injected fluidic material exceeds a predetermined value, permitting the fluidic material to enter a pressure chamber defined within the tubular member. In an exemplary embodiment, at least a portion of the tubular member has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the portion of the tubular member includes the pressurized portion of the tubular member.

[000605] A method of radially expanding and plastically deforming an expandable tubular member has been described that includes limiting the amount of radial expansion of the expandable tubular member. In an exemplary embodiment, limiting the amount of radial expansion of the expandable tubular member includes: coupling another tubular member to the expandable tubular member that limits the amount of the radial expansion of the expandable tubular member. In an exemplary embodiment, the other tubular member defines one or more slots. In an exemplary embodiment, the other tubular member has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation.

[000606] An apparatus for radially expanding a tubular member has been described that includes an expandable tubular member; an expansion device coupled to the expandable tubular member for

radially expanding and plastically deforming the expandable tubular member; and an tubular expansion limiter coupled to the expandable tubular member for limiting the degree to which the expandable tubular member may be radially expanded and plastically deformed. In an exemplary embodiment, the tubular expansion limiter includes a tubular member that defines one or more slots. In an exemplary embodiment, the tubular expansion limiter comprises a tubular member that has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the apparatus further includes: a locking device positioned within the expandable tubular member releasably coupled to the expandable tubular member; a tubular support member positioned within the expandable tubular member coupled to the locking device and the expansion device. In an exemplary embodiment, at least a portion of the expandable tubular member has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the apparatus further includes: means for transmitting torque between the expandable tubular member and the tubular support member. In an exemplary embodiment, the apparatus further includes: means for sealing the interface between the expandable tubular member and the tubular support member. In an exemplary embodiment, the apparatus further includes means for sealing the interface between the expandable tubular member and the tubular support member. In an exemplary embodiment, the apparatus further includes: means for sensing the operating pressure within the tubular support member. In an exemplary embodiment, the apparatus further includes: means for pressurizing the interior of the tubular support member.

[000607] An apparatus for radially expanding a tubular member has been described that includes: an expandable tubular member; an expansion device coupled to the expandable tubular member for radially expanding and plastically deforming the expandable tubular member; an tubular expansion limiter coupled to the expandable tubular member for limiting the degree to which the expandable tubular member may be radially expanded and plastically deformed; a locking device positioned within the expandable tubular member releasably coupled to the expandable tubular member; a tubular support member positioned within the expandable tubular member coupled to the locking device and the expansion device; means for transmitting torque between the expandable tubular member and the tubular support member; means for sealing the interface between the expandable tubular member and the tubular support member; means for sensing the operating pressure within the tubular support member; and means for pressurizing the interior of the tubular support member; wherein at least a portion of the expandable tubular member has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation.

[000608] A method for radially expanding a tubular member has been described that includes positioning a tubular member and an adjustable expansion device within a preexisting structure; radially expanding and plastically deforming at least a portion of the tubular member by pressurizing an interior portion of the tubular member; limiting the extent to which the portion of the tubular member is radially

expanded and plastically deformed by pressurizing the interior of the tubular member; increasing the size of the adjustable expansion device; and radially expanding and plastically deforming another portion of the tubular member by displacing the adjustable expansion device relative to the tubular member. In an exemplary embodiment, the method further includes sensing an operating pressure within the tubular member. In an exemplary embodiment, radially expanding and plastically deforming at least a portion of the tubular member by pressurizing an interior portion of the tubular member includes: injecting fluidic material into the tubular member; sensing the operating pressure of the injected fluidic material; and if the operating pressure of the injected fluidic material exceeds a predetermined value, permitting the fluidic material to enter a pressure chamber defined within the tubular member. In an exemplary embodiment, at least a portion of the tubular member has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, limiting the extent to which the portion of the tubular member is radially expanded and plastically deformed by pressurizing the interior of the tubular member includes: applying a force to the exterior of the tubular member. In an exemplary embodiment, applying a force to the exterior of the tubular member includes: applying a variable force to the exterior of the tubular member.

[000609] A system for radially expanding a tubular member has been described that includes means for positioning a tubular member and an adjustable expansion device within a preexisting structure; means for radially expanding and plastically deforming at least a portion of the tubular member by pressurizing an interior portion of the tubular member; means for limiting the extent to which the portion of the tubular member is radially expanded and plastically deformed by pressurizing the interior of the tubular member; means for increasing the size of the adjustable expansion device; and means for radially expanding and plastically deforming another portion of the tubular member by displacing the adjustable expansion device relative to the tubular member. In an exemplary embodiment, the method further includes: means for sensing an operating pressure within the tubular member. In an exemplary embodiment, means for radially expanding and plastically deforming at least a portion of the tubular member by pressurizing an interior portion of the tubular member includes: means for injecting fluidic material into the tubular member; means for sensing the operating pressure of the injected fluidic material; and if the operating pressure of the injected fluidic material exceeds a predetermined value, means for permitting the fluidic material to enter a pressure chamber defined within the tubular member. In an exemplary embodiment, at least a portion of the tubular member has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, means for limiting the extent to which the portion of the tubular member is radially expanded and plastically deformed by pressurizing the interior of the tubular member includes: means for applying a force to the exterior of the tubular member. In an exemplary embodiment, wherein means for applying a force to the exterior of the tubular member includes: means for applying a variable force to the exterior of the tubular member.

[000610] An apparatus for radially expanding an expandable tubular member has been described that includes an expandable tubular member; a locking device positioned within the expandable tubular member releasably coupled to the expandable tubular member; an actuator positioned within the expandable tubular member coupled to the locking device; a tubular support member positioned within the expandable tubular member coupled to the actuator; a first expansion device coupled to the tubular support member; a second expansion device coupled to the tubular support member; and an expandable tubular sleeve coupled to the second expansion device. In an exemplary embodiment, the outside diameters of the first and second expansion devices are unequal. In an exemplary embodiment, the outside diameter of the first expansion device is greater than the outside diameter of the second expansion device. In an exemplary embodiment, at least a portion of the expandable tubular member has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, at least a portion of the expandable tubular sleeve has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the outside diameters of the first and second expansion devices are both less than or equal to the outside diameter of the expandable tubular member. In an exemplary embodiment, the outside diameter of the expandable tubular sleeve is less than or equal to the outside diameter of the expandable tubular member. In an exemplary embodiment, the apparatus further includes means for transmitting torque between the expandable tubular member and the tubular support member. In an exemplary embodiment, the apparatus further includes means for pressurizing the interior of the tubular support member. In an exemplary embodiment, the apparatus further includes means for limiting axial displacement of the expandable tubular sleeve. In an exemplary embodiment, the apparatus further includes means for limiting axial displacement of the expandable tubular member. In an exemplary embodiment, the apparatus further includes means for transmitting torque from the tubular support member to the means for limiting axial displacement of the expandable tubular sleeve. In an exemplary embodiment, the apparatus further includes means for displacing the first expansion device relative to the expandable tubular member to radially expand and plastically deform the expandable tubular member. In an exemplary embodiment, the apparatus further includes means for displacing the second expansion device relative to the expandable tubular sleeve to radially expand and plastically deform the expandable tubular sleeve. In an exemplary embodiment, the wall thickness of the expandable tubular sleeve is variable. In an exemplary embodiment, the expandable tubular sleeve includes means for sealing an interface between the expandable tubular sleeve and the interior surface of the expandable tubular member.

[000611] An apparatus for radially expanding an expandable tubular member has been described that includes: an expandable tubular member; a locking device positioned within the expandable tubular member releasably coupled to the expandable tubular member; an actuator positioned within the expandable tubular member coupled to the locking device; a tubular support member positioned within

the expandable tubular member coupled to the actuator; a first expansion device coupled to the tubular support member; a second expansion device coupled to the tubular support member; an expandable tubular sleeve coupled to the second expansion device; means for transmitting torque between the expandable tubular member and the tubular support member; means for pressurizing the interior of the tubular support member; means for limiting axial displacement of the expandable tubular sleeve; means for limiting axial displacement of the expandable tubular member; means for transmitting torque from the tubular support member to the means for limiting axial displacement of the expandable tubular sleeve; means for displacing the first expansion device relative to the expandable tubular member to radially expand and plastically deform the expandable tubular member; and means for displacing the second expansion device relative to the expandable tubular sleeve to radially expand and plastically deform the expandable tubular sleeve; wherein the outside diameter of the first expansion device is greater than the outside diameter of the second expansion device; wherein at least a portion of the expandable tubular member has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation; wherein at least a portion of the expandable tubular sleeve has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation; wherein the outside diameters of the first and second expansion devices are both less than or equal to the outside diameter of the expandable tubular member; wherein the outside diameter of the expandable tubular sleeve is less than or equal to the outside diameter of the expandable tubular member; wherein the wall thickness of the expandable tubular sleeve is variable; and wherein the expandable tubular sleeve comprises means for sealing an interface between the expandable tubular sleeve and the interior surface of the expandable tubular member.

[000612] A method for radially expanding a tubular member has been described that includes positioning an expandable tubular member and an expandable tubular sleeve within a preexisting structure; radially expanding and plastically deforming at least a portion of the expandable tubular member onto the expandable tubular sleeve; and radially expanding and plastically deforming at least a portion of the expandable tubular sleeve. In an exemplary embodiment, the method further includes radially expanding and plastically deforming at least a portion of the expandable tubular member while simultaneously radially expanding and plastically deforming at least a portion of the expandable tubular sleeve. In an exemplary embodiment, the method further includes radially expanding and plastically deforming another portion of the expandable tubular member after radially expanding and plastically deforming the portion of the expandable tubular sleeve. In an exemplary embodiment, at least a portion of the expandable tubular member has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, at least a portion of the expandable tubular sleeve has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the wall thickness of the expandable tubular sleeve is

variable. In an exemplary embodiment, the method further includes sealing an interface between the exterior surface of the expandable tubular sleeve and the interior surface of the expandable tubular member.

[000613] A system for radially expanding a tubular member has been described that includes means for positioning an expandable tubular member and an expandable tubular sleeve within a preexisting structure; means for radially expanding and plastically deforming at least a portion of the expandable tubular member onto the expandable tubular sleeve; and means for radially expanding and plastically deforming at least a portion of the expandable tubular sleeve. In an exemplary embodiment, the system further includes means for radially expanding and plastically deforming at least a portion of the expandable tubular member while simultaneously radially expanding and plastically deforming at least a portion of the expandable tubular sleeve. In an exemplary embodiment, the system further includes means for radially expanding and plastically deforming another portion of the expandable tubular member after radially expanding and plastically deforming the portion of the expandable tubular sleeve. In an exemplary embodiment, at least a portion of the expandable tubular member has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, at least a portion of the expandable tubular sleeve has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the wall thickness of the expandable tubular sleeve is variable. In an exemplary embodiment, the system further includes sealing an interface between the exterior surface of the expandable tubular sleeve and the interior surface of the expandable tubular member.

[000614] An apparatus for radially expanding an expandable tubular member has been described that includes an expandable tubular member; a locking device positioned within the expandable tubular member releasably coupled to the expandable tubular member; an actuator positioned within the expandable tubular member coupled to the locking device; a tubular support member positioned within the expandable tubular member coupled to the actuator; an adjustable expansion device coupled to the tubular support member; a non-adjustable expansion device coupled to the tubular support member; and an expandable tubular sleeve coupled to the non-adjustable expansion device. In an exemplary embodiment, at least a portion of the expandable tubular member has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, at least a portion of the expandable tubular sleeve has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the outside diameters of the adjustable and non-adjustable expansion devices are both less than or equal to the outside diameter of the expandable tubular member. In an exemplary embodiment, the outside diameter of the expandable tubular sleeve is less than or equal to the outside diameter of the expandable tubular member. In an exemplary embodiment, the apparatus further includes means for transmitting torque between the

expandable tubular member and the tubular support member. In an exemplary embodiment, the apparatus further includes means for pressurizing the interior of the tubular support member. In an exemplary embodiment, the apparatus further includes means for limiting axial displacement of the expandable tubular sleeve. In an exemplary embodiment, the apparatus further includes means for limiting axial displacement of the expandable tubular member. In an exemplary embodiment, the apparatus further includes means for transmitting torque from the tubular support member to the means for limiting axial displacement of the expandable tubular sleeve. In an exemplary embodiment, the apparatus further includes means for transmitting torque from the tubular support member to the means for limiting axial displacement of the expandable tubular member. In an exemplary embodiment, the apparatus further includes means for displacing the adjustable expansion device relative to the expandable tubular member to radially expand and plastically deform the expandable tubular member. In an exemplary embodiment, the apparatus further includes means for pulling the adjustable expansion device through the expandable tubular member to radially expand and plastically deform the expandable tubular member. In an exemplary embodiment, the apparatus further includes fluid powered means for pulling the adjustable expansion device through the expandable tubular member to radially expand and plastically deform the expandable tubular member. In an exemplary embodiment, the apparatus further includes means for displacing the non-adjustable expansion device relative to the expandable tubular sleeve to radially expand and plastically deform the expandable tubular sleeve. In an exemplary embodiment, the apparatus further includes fluid powered means for pulling the non-adjustable expansion device through the expandable tubular sleeve to radially expand and plastically deform the expandable tubular sleeve. In an exemplary embodiment, the wall thickness of the expandable tubular sleeve is variable. In an exemplary embodiment, the expandable tubular sleeve includes means for sealing an interface between the expandable tubular sleeve and the interior surface of the expandable tubular member.

[000615] An apparatus for radially expanding an expandable tubular member has been described that includes an expandable tubular member; a locking device positioned within the expandable tubular member releasably coupled to the expandable tubular member; an actuator positioned within the expandable tubular member coupled to the locking device; a tubular support member positioned within the expandable tubular member coupled to the actuator; an adjustable expansion device coupled to the tubular support member; a non-adjustable expansion device coupled to the tubular support member; an expandable tubular sleeve coupled to the non-adjustable expansion device; means for transmitting torque between the expandable tubular member and the tubular support member; means for pressurizing the interior of the tubular support member; means for limiting axial displacement of the expandable tubular sleeve; means for limiting axial displacement of the expandable tubular member; means for transmitting torque from the tubular support member to the means for limiting axial displacement of the expandable tubular sleeve; means for transmitting torque from the tubular support member to the means for limiting axial displacement of the expandable tubular member; fluid powered means for pulling the adjustable

expansion device through the expandable tubular member to radially expand and plastically deform the expandable tubular member; and fluid powered means for pulling the non-adjustable expansion device through the expandable tubular sleeve to radially expand and plastically deform the expandable tubular sleeve; wherein at least a portion of the expandable tubular member has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation; wherein at least a portion of the expandable tubular sleeve has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation; wherein the outside diameters of the adjustable and non-adjustable expansion devices are both less than or equal to the outside diameter of the expandable tubular member; wherein the outside diameter of the expandable tubular sleeve is less than or equal to the outside diameter of the expandable tubular member; wherein the wall thickness of the expandable tubular sleeve is variable; and wherein the expandable tubular sleeve comprises means for sealing an interface between the expandable tubular sleeve and the interior surface of the expandable tubular member.

[000616] A method for radially expanding a tubular member has been described that includes positioning an expandable tubular member, an expandable tubular sleeve, and an adjustable expansion device within a preexisting structure; increasing the size of the adjustable expansion device; radially expanding and plastically deforming at least a portion of the expandable tubular member onto the expandable tubular sleeve using the adjustable expansion device; and radially expanding and plastically deforming at least a portion of the expandable tubular sleeve. In an exemplary embodiment, the method further includes radially expanding and plastically deforming at least a portion of the expandable tubular member while simultaneously radially expanding and plastically deforming at least a portion of the expandable tubular sleeve. In an exemplary embodiment, the method further includes radially expanding and plastically deforming another portion of the expandable tubular member after radially expanding and plastically deforming the portion of the expandable tubular sleeve. In an exemplary embodiment, at least a portion of the expandable tubular member has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, at least a portion of the expandable tubular sleeve has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the wall thickness of the expandable tubular sleeve is variable. In an exemplary embodiment, the method further includes sealing an interface between the exterior surface of the expandable tubular sleeve and the interior surface of the expandable tubular member. In an exemplary embodiment, the method further includes pulling the adjustable expansion device through the expandable tubular member. In an exemplary embodiment, the method further includes pulling the adjustable expansion device through the expandable tubular member using fluid pressure.

[000617] A system for radially expanding a tubular member has been described that includes means for positioning an expandable tubular member, an expandable tubular sleeve, and an adjustable

expansion device within a preexisting structure; means for increasing the size of the adjustable expansion device; means for radially expanding and plastically deforming at least a portion of the expandable tubular member onto the expandable tubular sleeve using the adjustable expansion device; and means for radially expanding and plastically deforming at least a portion of the expandable tubular sleeve. In an exemplary embodiment, the system further includes means for radially expanding and plastically deforming at least a portion of the expandable tubular member while simultaneously radially expanding and plastically deforming at least a portion of the expandable tubular sleeve. In an exemplary embodiment, the system further includes means for radially expanding and plastically deforming another portion of the expandable tubular member after radially expanding and plastically deforming the portion of the expandable tubular sleeve. In an exemplary embodiment, at least a portion of the expandable tubular member has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, at least a portion of the expandable tubular sleeve has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the wall thickness of the expandable tubular sleeve is variable. In an exemplary embodiment, the system further includes means for sealing an interface between the exterior surface of the expandable tubular sleeve and the interior surface of the expandable tubular member. In an exemplary embodiment, the system further includes means for pulling the adjustable expansion device through the expandable tubular member. In an exemplary embodiment, the system further includes means for pulling the adjustable expansion device through the expandable tubular member using fluid pressure.

[000618] An apparatus for radially expanding an expandable tubular member has been described that includes an expandable tubular member; a locking device positioned within the expandable tubular member releasably coupled to the expandable tubular member; an actuator positioned within the expandable tubular member coupled to the locking device; a tubular support member positioned within the expandable tubular member coupled to the actuator; and an adjustable expansion device positioned within the expandable tubular member coupled to the tubular support member. In an exemplary embodiment, at least a portion of the expandable tubular member has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the apparatus further includes an expandable tubular sleeve coupled to an end of the expandable tubular member that receives the adjustable expansion device. In an exemplary embodiment, at least a portion of the expandable tubular sleeve has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the apparatus further includes means for transmitting torque between the expandable tubular member and the tubular support member. In an exemplary embodiment, the apparatus further includes means for pressurizing the interior of the tubular support member. In an exemplary embodiment, the actuator includes means for displacing the adjustable

expansion device relative to the expandable tubular member to radially expand and plastically deform the expandable tubular member. In an exemplary embodiment, the actuator further includes means for pulling the adjustable expansion device through the expandable tubular member to radially expand and plastically deform the expandable tubular member. In an exemplary embodiment, the actuator further includes fluid powered means for pulling the adjustable expansion device through the expandable tubular member to radially expand and plastically deform the expandable tubular member. In an exemplary embodiment, the apparatus further includes means for adjusting the size of the adjustable expansion device.

[000619] An apparatus for radially expanding an expandable tubular member has been described that includes an expandable tubular member; a locking device positioned within the expandable tubular member releasably coupled to the expandable tubular member; an actuator positioned within the expandable tubular member coupled to the locking device; a tubular support member positioned within the expandable tubular member coupled to the actuator; an adjustable expansion device positioned within the expandable tubular member coupled to the tubular support member; an expandable tubular sleeve coupled to an end of the expandable tubular member that receives the adjustable expansion device; means for transmitting torque between the expandable tubular member and the tubular support member; means for pressurizing the interior of the tubular support member; means for adjusting the size of the adjustable expansion device; and fluid powered means for pulling the adjustable expansion device through the expandable tubular member to radially expand and plastically deform the expandable tubular member; wherein at least a portion of the expandable tubular member has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation; and wherein at least a portion of the expandable tubular sleeve has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation.

[000620] A method for radially expanding a tubular member has been described that includes positioning an expandable tubular member, an expandable tubular sleeve, and an adjustable expansion device within a preexisting structure; increasing the size of the adjustable expansion device to radially expand and plastically deform at least a portion of at least one of the expandable tubular member and the expandable tubular sleeve; and radially expanding and plastically deforming at least another portion of the expandable tubular member using the adjustable expansion device. In an exemplary embodiment, at least a portion of the expandable tubular member has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, at least a portion of the expandable tubular sleeve has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the method further includes pulling the adjustable expansion device through the expandable tubular member. In an exemplary embodiment, the method

further includes pulling the adjustable expansion device through the expandable tubular member using fluid pressure.

[000621] A system for radially expanding a tubular member has been described that includes means for positioning an expandable tubular member, an expandable tubular sleeve, and an adjustable expansion device within a preexisting structure; means for increasing the size of the adjustable expansion device to radially expand and plastically deform at least a portion of at least one of the expandable tubular member and the expandable tubular sleeve; and means for radially expanding and plastically deforming at least another portion of the expandable tubular member using the adjustable expansion device. In an exemplary embodiment, at least a portion of the expandable tubular member has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, at least a portion of the expandable tubular sleeve has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation. In an exemplary embodiment, the system further includes means for pulling the adjustable expansion device through the expandable tubular member. In an exemplary embodiment, the system further includes means for pulling the adjustable expansion device through the expandable tubular member using fluid pressure.

[000622] A method for manufacturing an expandable member used to complete a structure by radially expanding and plastically deforming the expandable member has been described that includes forming the expandable member from a steel alloy comprising a charpy energy of at least about 90 ft-lbs.

[000623] An expandable member for use in completing a structure by radially expanding and plastically deforming the expandable member has been described that includes a steel alloy comprising a charpy energy of at least about 90 ft-lbs.

[000624] A structural completion positioned within a structure has been described that includes one or more radially expanded and plastically deformed expandable members positioned within the structure; wherein one or more of the radially expanded and plastically deformed expandable members are fabricated from a steel alloy comprising a charpy energy of at least about 90 ft-lbs.

[000625] A method for manufacturing an expandable member used to complete a structure by radially expanding and plastically deforming the expandable member has been described that includes forming the expandable member from a steel alloy comprising a weight percentage of carbon of less than about 0.08%.

[000626] An expandable member for use in completing a wellbore by radially expanding and plastically deforming the expandable member at a downhole location in the wellbore has been described that includes a steel alloy comprising a weight percentage of carbon of less than about 0.08%.

[000627] A structural completion has been described that includes one or more radially expanded and plastically deformed expandable members positioned within the wellbore; wherein one or more of the radially expanded and plastically deformed expandable members are fabricated from a steel alloy comprising a weight percentage of carbon of less than about 0.08%.

[000628] A method for manufacturing an expandable member used to complete a structure by radially expanding and plastically deforming the expandable member has been described that includes forming the expandable member from a steel alloy comprising a weight percentage of carbon of less than about 0.20% and a charpy V-notch impact toughness of at least about 6 joules.

[000629] An expandable member for use in completing a structure by radially expanding and plastically deforming the expandable member has been described that includes a steel alloy comprising a weight percentage of carbon of less than about 0.20% and a charpy V-notch impact toughness of at least about 6 joules.

[000630] A structural completion has been described that includes one or more radially expanded and plastically deformed expandable members; wherein one or more of the radially expanded and plastically deformed expandable members are fabricated from a steel alloy comprising a weight percentage of carbon of less than about 0.20% and a charpy V-notch impact toughness of at least about 6 joules.

[000631] A method for manufacturing an expandable member used to complete a structure by radially expanding and plastically deforming the expandable member has been described that includes forming the expandable member from a steel alloy comprising the following ranges of weight percentages: C, from about 0.002 to about 0.08; Si, from about 0.009 to about 0.30; Mn, from about 0.10 to about 1.92; P, from about 0.004 to about 0.07; S, from about 0.0008 to about 0.006; Al, up to about 0.04; N, up to about 0.01; Cu, up to about 0.3; Cr, up to about 0.5; Ni, up to about 18; Nb, up to about 0.12; Ti, up to about 0.6; Co, up to about 9; and Mo, up to about 5.

[000632] An expandable member for use in completing a structure by radially expanding and plastically deforming the expandable member has been described that includes a steel alloy comprising the following ranges of weight percentages: C, from about 0.002 to about 0.08; Si, from about 0.009 to about 0.30; Mn, from about 0.10 to about 1.92; P, from about 0.004 to about 0.07; S, from about 0.0008 to about 0.006; Al, up to about 0.04; N, up to about 0.01; Cu, up to about 0.3; Cr, up to about 0.5; Ni, up to about 18; Nb, up to about 0.12; Ti, up to about 0.6; Co, up to about 9; and Mo, up to about 5.

[000633] A structural completion has been described that includes one or more radially expanded and plastically deformed expandable members; wherein one or more of the radially expanded and plastically deformed expandable members are fabricated from a steel alloy comprising the following ranges of weight percentages: C, from about 0.002 to about 0.08; Si, from about 0.009 to about 0.30; Mn, from about 0.10 to about 1.92; P, from about 0.004 to about 0.07; S, from about 0.0008 to about 0.006; Al, up to about 0.04; N, up to about 0.01; Cu, up to about 0.3; Cr, up to about 0.5; Ni, up to about 18; Nb, up to about 0.12; Ti, up to about 0.6; Co, up to about 9; and Mo, up to about 5.

[000634] A method for manufacturing an expandable tubular member used to complete a structure by radially expanding and plastically deforming the expandable member has been described that includes forming the expandable tubular member with a ratio of an outside diameter of the expandable tubular member to a wall thickness of the expandable tubular member ranging from about 12 to 22.

[000635] An expandable member for use in completing a structure by radially expanding and plastically deforming the expandable member has been described that includes an expandable tubular member with a ratio of an outside diameter of the expandable tubular member to a wall thickness of the expandable tubular member ranging from about 12 to 22.

[000636] A structural completion has been described that includes one or more radially expanded and plastically deformed expandable members positioned within the structure; wherein one or more of the radially expanded and plastically deformed expandable members are fabricated from an expandable tubular member with a ratio of an outside diameter of the expandable tubular member to a wall thickness of the expandable tubular member ranging from about 12 to 22.

[000637] A method of constructing a structure has been described that includes radially expanding and plastically deforming an expandable member; wherein an outer portion of the wall thickness of the radially expanded and plastically deformed expandable member comprises tensile residual stresses.

[000638] A structural completion has been described that includes one or more radially expanded and plastically deformed expandable members; wherein an outer portion of the wall thickness of one or more of the radially expanded and plastically deformed expandable members comprises tensile residual stresses.

[000639] A method of constructing a structure using an expandable tubular member has been described that includes strain aging the expandable member; and then radially expanding and plastically deforming the expandable member.

[000640] A method for manufacturing a tubular member used to complete a wellbore by radially expanding the tubular member at a downhole location in the wellbore has been described that includes forming a steel alloy comprising a concentration of carbon between approximately 0.002% and 0.08% by weight of the steel alloy. In an exemplary embodiment, the method further includes forming the steel alloy with a concentration of niobium comprising between approximately 0.015% and 0.12% by weight of the steel alloy. In an exemplary embodiment, the method further includes forming the steel alloy with low concentrations of niobium and titanium; and limiting the total concentration of niobium and titanium to less than approximately 0.6% by weight of the steel alloy.

[000641] An expandable tubular member fabricated from a steel alloy has been described that includes a concentration of carbon between approximately 0.002% and 0.08% by weight of the steel alloy.

[000642] A method for manufacturing an expandable tubular member used to complete a wellbore completion within a wellbore that traverses a subterranean formation by radially expanding and plastically deforming the expandable tubular member within the wellbore has been described that includes forming the expandable tubular member from a steel alloy comprising a charpy energy of at least about 90 ft-lbs; forming the expandable member from a steel alloy comprising a charpy V-notch impact toughness of at least about 6 joules; forming the expandable member from a steel alloy comprising the following ranges of weight percentages: C, from about 0.002 to about 0.08; Si, from

about 0.009 to about 0.30; Mn, from about 0.10 to about 1.92; P, from about 0.004 to about 0.07; S, from about 0.0008 to about 0.006; Al, up to about 0.04; N, up to about 0.01; Cu, up to about 0.3; Cr, up to about 0.5; Ni, up to about 18; Nb, up to about 0.12; Ti, up to about 0.6; Co, up to about 9; and Mo, up to about 5; forming the expandable tubular member with a ratio of an outside diameter of the expandable tubular member to a wall thickness of the expandable tubular member ranging from about 12 to 22; and strain aging the expandable tubular member prior to the radial expansion and plastic deformation of the expandable tubular member within the wellbore.

[000643] An expandable tubular member for use in completing a wellbore completion within a wellbore that traverses a subterranean formation by radially expanding and plastically deforming the expandable tubular member within the wellbore has been described that includes a steel alloy having a charpy energy of at least about 90 ft-lbs; a steel alloy having a charpy V-notch impact toughness of at least about 6 joules; and a steel alloy comprising the following ranges of weight percentages: C, from about 0.002 to about 0.08; Si, from about 0.009 to about 0.30; Mn, from about 0.10 to about 1.92; P, from about 0.004 to about 0.07; S, from about 0.0008 to about 0.006; Al, up to about 0.04; N, up to about 0.01; Cu, up to about 0.3; Cr, up to about 0.5; Ni, up to about 18; Nb, up to about 0.12; Ti, up to about 0.6; Co, up to about 9; and Mo, up to about 5; wherein a ratio of an outside diameter of the expandable tubular member to a wall thickness of the expandable tubular member ranges from about 12 to 22; and wherein the expandable tubular member is strain aged prior to the radial expansion and plastic deformation of the expandable tubular member within the wellbore.

[000644] A wellbore completion positioned within a wellbore that traverses a subterranean formation has been described that includes one or more radially expanded and plastically deformed expandable tubular members positioned within the wellbore completion; wherein one or more of the radially expanded and plastically deformed expandable tubular members are fabricated from a steel alloy comprising a charpy energy of at least about 90 ft-lbs; a steel alloy having a charpy V-notch impact toughness of at least about 6 joules; and a steel alloy comprising the following ranges of weight percentages: C, from about 0.002 to about 0.08; Si, from about 0.009 to about 0.30; Mn, from about 0.10 to about 1.92; P, from about 0.004 to about 0.07; S, from about 0.0008 to about 0.006; Al, up to about 0.04; N, up to about 0.01; Cu, up to about 0.3; Cr, up to about 0.5; Ni, up to about 18; Nb, up to about 0.12; Ti, up to about 0.6; Co, up to about 9; and Mo, up to about 5; wherein at least one of the expandable tubular members comprises a ratio of an outside diameter of the expandable member to a wall thickness of the expandable member ranging from about 12 to 22; wherein an outer portion of the wall thickness of at least one of the radially expanded and plastically deformed expandable tubular members comprises tensile residual stresses; and wherein at least one of the expandable tubular members is strain aged prior to the radial expansion and plastic deformation of the expandable tubular member within the wellbore.

[000645] A method of radially expanding and plastically deforming a tubular member using an expansion device has been described that includes quenching and tempering the tubular member; positioning the tubular member within a preexisting structure; and radially expanding and plastically

deforming the tubular member. In an exemplary embodiment, the yield strength of the tubular member ranges from about 76.8 ksi to 88.8 ksi. In an exemplary embodiment, the ratio of the yield strength to the tensile strength of the tubular member ranges from about 0.82 to 0.86. In an exemplary embodiment, the longitudinal elongation of the tubular member prior to failure ranges from about 14.8% to 22.0%. In an exemplary embodiment, the width reduction of the tubular member prior to failure ranges from about 32% to 44.0%. In an exemplary embodiment, the width thickness reduction of the tubular member prior to failure ranges from about 41.0% to 45%. In an exemplary embodiment, the anisotropy of the tubular member ranges from about 0.65 to 1.03. In an exemplary embodiment, the absorbed energy in the longitudinal direction of the tubular member ranges from about 125 to 145 ft-lbs. In an exemplary embodiment, the absorbed energy in the transverse direction of the tubular member ranges from about 59 to 59 ft-lbs. In an exemplary embodiment, the absorbed energy in a welded portion of the tubular member ranges from about 174 to 176 ft-lbs. In an exemplary embodiment, a flared expansion of an end of tubular member ranged from about 42 to 52%. In an exemplary embodiment, the tubular member comprises, by weight percentage: 0.27 C; 0.14 Si; 1.28 Mn; 0.009 P; 0.005 S; and 0.14 Cr. In an exemplary embodiment, the quenching of the tubular member is provided at about 970 C; and the tempering the tubular member is provided at about 670 C.

[000646] A radially expandable and plastically deformable tubular member has been described that includes a yield strength ranging from about 76.8 ksi to 88.8 ksi, a ratio of the yield strength to a tensile strength of the tubular member ranging from about 0.82 to 0.86, a longitudinal elongation of the tubular member prior to failure ranging from about 14.8% to 22.0%, a width reduction of the tubular member prior to failure ranging from about 32% to 44.0%, a width thickness reduction of the tubular member prior to failure ranges from about 41.0% to 45%, and an anisotropy of the tubular member ranges from about 0.65 to 1.03. In an exemplary embodiment, an absorbed energy in the longitudinal direction of the tubular member ranges from about 125 to 145 ft-lbs. In an exemplary embodiment, the absorbed energy in the transverse direction of the tubular member ranges from about 59 to 59 ft-lbs. In an exemplary embodiment, the absorbed energy in a welded portion of the tubular member ranges from about 174 to 176 ft-lbs. In an exemplary embodiment, a flared expansion of an end of tubular member ranged from about 42 to 52%. In an exemplary embodiment, the tubular member comprises, by weight percentage: 0.27 C; 0.14 Si; 1.28 Mn; 0.009 P; 0.005 S; and 0.14 Cr.

[000647] A radially expandable and plastically deformable tubular member has been described that includes: a yield strength ranging from about 40.0 ksi to 100.0 ksi; a ratio of the yield strength to a tensile strength of the tubular member ranging from about 0.40 to 0.85; a longitudinal elongation of the tubular member prior to failure ranging from at least about 22.0 to 35.0%; a width reduction of the tubular member prior to failure ranging from at least about 30.0% to 45.0%; a width thickness reduction of the tubular member prior to failure ranges from at least about 30.0% to 45.0%; and an anisotropy of the tubular member ranges from at least about 0.65 to 1.50. In an exemplary embodiment, an absorbed energy in the longitudinal direction of the tubular member is at least about 80 ft-lbs. In an exemplary

embodiment, the absorbed energy in the transverse direction of the tubular member is at least about 60 ft-lbs. In an exemplary embodiment, the absorbed energy in a welded portion of the tubular member is at least about 60 ft-lbs. In an exemplary embodiment, a flared expansion of an end of tubular member ranges from at least about 45 to 75%.

[000648] A method of manufacturing a tubular member has been described that includes fabricating a tubular member; positioning the tubular member within a preexisting structure; radially expanding and plastically deforming the tubular member within the preexisting structure; and baking the tubular member within the preexisting structure. In an exemplary embodiment, the preexisting structure comprises a wellbore. In an exemplary embodiment, the fabricated tubular member comprises a dual phase steel pipe. In an exemplary embodiment, the fabricated tubular member comprises a microstructure comprising about 15 to 30% martensite; and ferrite. In an exemplary embodiment, the fabricated tubular member comprises, by weight percentage: 0.1 C; 1.2 Mn; and 0.3 Si. In an exemplary embodiment, the fabricated tubular member comprises a TRIP steel pipe. In an exemplary embodiment, fabricating the tubular member comprises: cold rolling the tubular member; and inter critical annealing the tubular member. In an exemplary embodiment, the fabricated tubular member comprises a dual phase steel pipe. In an exemplary embodiment, prior to the cold rolling, the fabricated tubular member comprises a microstructure comprising ferrite and pearlite. In an exemplary embodiment, the inter critical annealing is performed at about 750 C. In an exemplary embodiment, after the inter critical annealing, the fabricated tubular member comprises a microstructure comprising ferrite and at least one of pearlite and austentite. In an exemplary embodiment, the method further comprising: cooling the tubular member after the inter critical annealing. In an exemplary embodiment, after the cooling, the tubular member comprises a microstructure comprising martensite. In an exemplary embodiment, the baking is provided at about 100 C to 250 C. In an exemplary embodiment, following at least a portion of the baking, the tubular member comprises a bake-hardened portion. In an exemplary embodiment, following at least a portion of the baking, the tubular member comprises a stress-relieved portion. In an exemplary embodiment, following at least a portion of the baking, the tubular member comprises a bake-hardened portion and a stress-relieved portion. In an exemplary embodiment, the cold rolling comprises: allowing the tubular member to cool over time from a first temperature to a second temperature along a temperature versus time curve; and at a plurality of stages along the curve, deforming the tubular member. In an exemplary embodiment, at a first stage along the curve, insoluble precipitates within the tubular member retard austentite growth. In an exemplary embodiment, at a first stage along the curve, deformation of the tubular member promotes precipitation. In an exemplary embodiment, at a second stage along the curve, insoluble precipitates within the tubular member inhibit recrystallization. In an exemplary embodiment, at a second stage along the curve, austentite grains are conditioned.

[000649] It is understood that variations may be made in the foregoing without departing from the scope of the invention. For example, the teachings of the present illustrative embodiments may be used to provide a wellbore casing, a pipeline, or a structural support. Furthermore, the elements and teachings

of the various illustrative embodiments may be combined in whole or in part in some or all of the illustrative embodiments. In addition, one or more of the elements and teachings of the various illustrative embodiments may be omitted, at least in part, and/or combined, at least in part, with one or more of the other elements and teachings of the various illustrative embodiments.

[000650] Although illustrative embodiments of the invention have been shown and described, a wide range of modification, changes and substitution is contemplated in the foregoing disclosure. In some instances, some features of the present invention may be employed without a corresponding use of the other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.

What is claimed is:

1. A method of forming a tubular liner within a preexisting structure, comprising:
positioning a tubular assembly within the preexisting structure; and
radially expanding and plastically deforming the tubular assembly within the preexisting structure;
wherein, prior to the radial expansion and plastic deformation of the tubular assembly, a predetermined portion of the tubular assembly has a lower yield point than another portion of the tubular assembly.

2. An expandable tubular member comprising a steel alloy comprising, by weight percentage, the following:
0.065 to 0.18% C,
0.006 to 1.44 % Mn,
0.006 to 0.02 % P,
0.001 to 0.004% S,
0.24 to 0.45% Si,
up to 0.16% Cu,
0.01 to 9.1% Ni, and
0.02 to 18.7% Cr.

3. An expandable tubular member, wherein the yield point of the expandable tubular member is at most about 46.9 to 61.7 ksi prior to a radial expansion and plastic deformation; and wherein the yield point of the expandable tubular member is at least about 65.9 to 74.4 ksi after the radial expansion and plastic deformation.

4. An expandable tubular member, wherein a yield point of the expandable tubular member after a radial expansion and plastic deformation is at least about 5.8 to 40 % greater than the yield point of the expandable tubular member prior to the radial expansion and plastic deformation.

5. An expandable tubular member, wherein the anisotropy of the expandable tubular member, prior to the radial expansion and plastic deformation, ranges from about 1.04 to at least about 1.92.

6. An expandable tubular member, wherein the expandability coefficient of the expandable tubular member, prior to the radial expansion and plastic deformation, is greater than 0.12.

7. An expandable tubular member, wherein the expandability coefficient of the expandable tubular member is greater than the expandability coefficient of another portion of the expandable tubular member.

8. An expandable tubular member, wherein the tubular member has a higher ductility and a lower yield point prior to a radial expansion and plastic deformation than after the radial expansion and plastic deformation.

9. A method of radially expanding and plastically deforming a tubular assembly comprising a first tubular member coupled to a second tubular member, comprising:

radially expanding and plastically deforming the tubular assembly within a preexisting structure; and

using less power to radially expand each unit length of the first tubular member than to radially expand each unit length of the second tubular member.

10. A method of manufacturing a tubular member, comprising:

processing a tubular member until the tubular member is characterized by one or more intermediate characteristics;

positioning the tubular member within a preexisting structure; and

processing the tubular member within the preexisting structure until the tubular member is characterized one or more final characteristics.

11. An apparatus, comprising:

an expandable tubular assembly; and

an expansion device coupled to the expandable tubular assembly;

wherein a predetermined portion of the expandable tubular assembly has a lower yield point than another portion of the expandable tubular assembly.

12. A method of determining the expandability of a selected tubular member, comprising:

determining an anisotropy value for the selected tubular member;

determining a strain hardening value for the selected tubular member; and

multiplying the anisotropy value times the strain hardening value to generate an expandability value for the selected tubular member.

13. A method of radially expanding and plastically deforming tubular members, comprising:

selecting a tubular member;

determining an anisotropy value for the selected tubular member;

determining a strain hardening value for the selected tubular member;

multiplying the anisotropy value times the strain hardening value to generate an expandability value for the selected tubular member; and

if the anisotropy value is greater than 0.12, then radially expanding and plastically deforming the selected tubular member.

14. A radially expandable tubular member apparatus comprising:

a first tubular member;

a second tubular member engaged with the first tubular member forming a joint; and

a sleeve overlapping and coupling the first and second tubular members at the joint;

wherein, prior to a radial expansion and plastic deformation of the apparatus, a predetermined portion of the apparatus has a lower yield point than another portion of the apparatus.

15. A method of joining radially expandable tubular members comprising:

providing a first tubular member;

engaging a second tubular member with the first tubular member to form a joint;

providing a sleeve;

mounting the sleeve for overlapping and coupling the first and second tubular members at the joint;

wherein the first tubular member, the second tubular member, and the sleeve define a tubular assembly; and

radially expanding and plastically deforming the tubular assembly;

wherein, prior to the radial expansion and plastic deformation, a predetermined portion of the tubular assembly has a lower yield point than another portion of the tubular assembly.

16. An expandable tubular member, wherein, if the carbon content of the tubular member is less than or equal to 0.12 percent, then the carbon equivalent value for the tubular member is less than 0.21; and wherein, if the carbon content of the tubular member is greater than 0.12 percent, then the carbon equivalent value for the tubular member is less than 0.36.

17. A method of selecting tubular members for radial expansion and plastic deformation, comprising:

selecting a tubular member from a collection of tubular member;

determining a carbon content of the selected tubular member;

determining a carbon equivalent value for the selected tubular member;

if the carbon content of the selected tubular member is less than or equal to 0.12 percent and the carbon equivalent value for the selected tubular member is less than 0.21, then determining that the selected tubular member is suitable for radial expansion and plastic deformation; and

if the carbon content of the selected tubular member is greater than 0.12 percent and the carbon equivalent value for the selected tubular member is less than 0.36, then determining that the selected tubular member is suitable for radial expansion and plastic deformation.

18. An expandable tubular member, comprising:

a tubular body;

wherein a yield point of an inner tubular portion of the tubular body is less than a yield point of an outer tubular portion of the tubular body.

19. A method of manufacturing an expandable tubular member, comprising:

providing a tubular member;

heat treating the tubular member; and

quenching the tubular member;

wherein following the quenching, the tubular member comprises a microstructure comprising a hard phase structure and a soft phase structure.

20. A method of radially expanding a tubular assembly, comprising:

radially expanding and plastically deforming a lower portion of the tubular assembly by pressurizing the interior of the lower portion of the tubular assembly; and

then, radially expanding and plastically deforming the remaining portion of the tubular assembly by contacting the interior of the tubular assembly with an expansion device.

21. A method of repairing a tubular assembly, comprising:
positioning a tubular patch within the tubular assembly; and
radially expanding and plastically deforming a tubular patch into engagement with the tubular assembly by pressurizing the interior of the tubular patch.

22. A method of radially expanding a tubular member, comprising:
accumulating a supply of pressurized fluid; and
controllably injecting the pressurized fluid into the interior of the tubular member.

23. An apparatus for radially expanding a tubular member, comprising:
a fluid reservoir;
a pump for pumping fluids out of the fluid reservoir;
an accumulator for receiving and accumulating the fluids pumped from the reservoir;
a flow control valve for controllably releasing the fluids accumulated within the reservoir; and
an expansion element for engaging the interior of the tubular member to define a pressure chamber within the tubular member and receiving the released accumulated fluids into the pressure chamber.

24. An apparatus for radially expanding a tubular member, comprising:
an expandable tubular member;
a locking device positioned within the expandable tubular member releasably coupled to the expandable tubular member;
a tubular support member positioned within the expandable tubular member coupled to the locking device; and
an adjustable expansion device positioned within the expandable tubular member coupled to the tubular support member;
wherein at least a portion of the expandable tubular member has a higher ductility and a lower yield point prior to the radial expansion and plastic deformation than after the radial expansion and plastic deformation.

25. A method for radially expanding a tubular member, comprising:
positioning a tubular member and an adjustable expansion device within a preexisting structure;
radially expanding and plastically deforming at least a portion of the tubular member by pressurizing an interior portion of the tubular member;
increasing the size of the adjustable expansion device; and
radially expanding and plastically deforming another portion of the tubular member by displacing the adjustable expansion device relative to the tubular member.

26. A method of radially expanding and plastically deforming an expandable tubular member, comprising:

limiting the amount of radial expansion of the expandable tubular member.

27. An apparatus for radially expanding a tubular member, comprising:
an expandable tubular member;
an expansion device coupled to the expandable tubular member for radially expanding and plastically deforming the expandable tubular member; and
an tubular expansion limiter coupled to the expandable tubular member for limiting the degree to which the expandable tubular member may be radially expanded and plastically deformed.

28. A method for radially expanding a tubular member, comprising:
positioning a tubular member and an adjustable expansion device within a preexisting structure;
radially expanding and plastically deforming at least a portion of the tubular member by pressurizing an interior portion of the tubular member;
limiting the extent to which the portion of the tubular member is radially expanded and plastically deformed by pressurizing the interior of the tubular member;
increasing the size of the adjustable expansion device; and
radially expanding and plastically deforming another portion of the tubular member by displacing the adjustable expansion device relative to the tubular member.

29. An apparatus for radially expanding an expandable tubular member, comprising:
an expandable tubular member;
a locking device positioned within the expandable tubular member releasably coupled to the expandable tubular member;
an actuator positioned within the expandable tubular member coupled to the locking device;
a tubular support member positioned within the expandable tubular member coupled to the actuator;
a first expansion device coupled to the tubular support member;
a second expansion device coupled to the tubular support member; and
an expandable tubular sleeve coupled to the second expansion device.

30. A method for radially expanding a tubular member, comprising:
positioning an expandable tubular member and an expandable tubular sleeve within a preexisting structure;
radially expanding and plastically deforming at least a portion of the expandable tubular member onto the expandable tubular sleeve; and
radially expanding and plastically deforming at least a portion of the expandable tubular sleeve.

31. An apparatus for radially expanding an expandable tubular member, comprising:
an expandable tubular member;
a locking device positioned within the expandable tubular member releasably coupled to the expandable tubular member;

an actuator positioned within the expandable tubular member coupled to the locking device;

a tubular support member positioned within the expandable tubular member coupled to the actuator;

an adjustable expansion device coupled to the tubular support member;

a non-adjustable expansion device coupled to the tubular support member; and

an expandable tubular sleeve coupled to the non-adjustable expansion device.

32. A method for radially expanding a tubular member, comprising:

positioning an expandable tubular member, an expandable tubular sleeve, and an adjustable expansion device within a preexisting structure;

increasing the size of the adjustable expansion device;

radially expanding and plastically deforming at least a portion of the expandable tubular member onto the expandable tubular sleeve using the adjustable expansion device; and

radially expanding and plastically deforming at least a portion of the expandable tubular sleeve.

33. An apparatus for radially expanding an expandable tubular member, comprising:

an expandable tubular member;

a locking device positioned within the expandable tubular member releasably coupled to the expandable tubular member;

an actuator positioned within the expandable tubular member coupled to the locking device;

a tubular support member positioned within the expandable tubular member coupled to the actuator; and

an adjustable expansion device positioned within the expandable tubular member coupled to the tubular support member.

34. A method for radially expanding a tubular member, comprising:

positioning an expandable tubular member, an expandable tubular sleeve, and an adjustable expansion device within a preexisting structure;

increasing the size of the adjustable expansion device to radially expand and plastically deform at least a portion of at least one of the expandable tubular member and the expandable tubular sleeve; and

radially expanding and plastically deforming at least another portion of the expandable tubular member using the adjustable expansion device.

35. A method for manufacturing an expandable member used to complete a structure by radially expanding and plastically deforming the expandable member comprising:

forming the expandable member from a steel alloy comprising a charpy energy of at least about 90 ft-lbs.

36. An expandable member for use in completing a structure by radially expanding and plastically deforming the expandable member, comprising:

a steel alloy comprising a charpy energy of at least about 90 ft-lbs.

37. A structural completion positioned within a structure, comprising:

one or more radially expanded and plastically deformed expandable members positioned within the structure;

wherein one or more of the radially expanded and plastically deformed expandable members are fabricated from a steel alloy comprising a charpy energy of at least about 90 ft-lbs.

38. A method for manufacturing an expandable member used to complete a structure by radially expanding and plastically deforming the expandable member, comprising:

forming the expandable member from a steel alloy comprising a weight percentage of carbon of less than about 0.08%.

39. An expandable member for use in completing a wellbore by radially expanding and plastically deforming the expandable member at a downhole location in the wellbore, comprising:

a steel alloy comprising a weight percentage of carbon of less than about 0.08%.

40. A structural completion, comprising:

one or more radially expanded and plastically deformed expandable members positioned within the wellbore;

wherein one or more of the radially expanded and plastically deformed expandable members are fabricated from a steel alloy comprising a weight percentage of carbon of less than about 0.08%.

41. A method for manufacturing an expandable member used to complete a structure by radially expanding and plastically deforming the expandable member, comprising:

forming the expandable member from a steel alloy comprising a weight percentage of carbon of less than about 0.20% and a charpy V-notch impact toughness of at least about 6 joules.

42. An expandable member for use in completing a structure by radially expanding and plastically deforming the expandable member, comprising:

a steel alloy comprising a weight percentage of carbon of less than about 0.20% and a charpy V-notch impact toughness of at least about 6 joules.

43. A structural completion, comprising:

one or more radially expanded and plastically deformed expandable members;

wherein one or more of the radially expanded and plastically deformed expandable members are fabricated from a steel alloy comprising a weight percentage of carbon of less than about 0.20% and a charpy V-notch impact toughness of at least about 6 joules.

44. A method for manufacturing an expandable member used to complete a structure by radially expanding and plastically deforming the expandable member, comprising:

forming the expandable member from a steel alloy comprising the following ranges of weight percentages:

C, from about 0.002 to about 0.08;

Si, from about 0.009 to about 0.30;

Mn, from about 0.10 to about 1.92;

P, from about 0.004 to about 0.07;

S, from about 0.0008 to about 0.006;

Al, up to about 0.04;

N, up to about 0.01;

Cu, up to about 0.3;

Cr, up to about 0.5;

Ni, up to about 18;

Nb, up to about 0.12;

Ti, up to about 0.6;

Co, up to about 9; and

Mo, up to about 5.

45. An expandable member for use in completing a structure by radially expanding and plastically deforming the expandable member, comprising:

a steel alloy comprising the following ranges of weight percentages:

C, from about 0.002 to about 0.08;

Si, from about 0.009 to about 0.30;

Mn, from about 0.10 to about 1.92;

P, from about 0.004 to about 0.07;

S, from about 0.0008 to about 0.006;

Al, up to about 0.04;

N, up to about 0.01;

Cu, up to about 0.3;

Cr, up to about 0.5;

Ni, up to about 18;

Nb, up to about 0.12;

Ti, up to about 0.6;

Co, up to about 9; and

Mo, up to about 5.

46. A structural completion, comprising:

one or more radially expanded and plastically deformed expandable members;

wherein one or more of the radially expanded and plastically deformed expandable members are fabricated from a steel alloy comprising the following ranges of weight percentages:

C, from about 0.002 to about 0.08;

Si, from about 0.009 to about 0.30;

Mn, from about 0.10 to about 1.92;

P, from about 0.004 to about 0.07;

S, from about 0.0008 to about 0.006;

Al, up to about 0.04;

N, up to about 0.01;

Cu, up to about 0.3;

Cr, up to about 0.5;

Ni, up to about 18;

Nb, up to about 0.12;

Ti, up to about 0.6;

Co, up to about 9; and

Mo, up to about 5.

47. A method for manufacturing an expandable tubular member used to complete a structure by radially expanding and plastically deforming the expandable member, comprising:

forming the expandable tubular member with a ratio of an outside diameter of the expandable tubular member to a wall thickness of the expandable tubular member ranging from about 12 to 22.

48. An expandable member for use in completing a structure by radially expanding and plastically deforming the expandable member, comprising:

an expandable tubular member with a ratio of an outside diameter of the expandable tubular member to a wall thickness of the expandable tubular member ranging from about 12 to 22.

49. A structural completion, comprising:

one or more radially expanded and plastically deformed expandable members positioned within the structure;

wherein one or more of the radially expanded and plastically deformed expandable members are fabricated from an expandable tubular member with a ratio of an outside diameter of the expandable tubular member to a wall thickness of the expandable tubular member ranging from about 12 to 22.

50. A method of constructing a structure, comprising:

radially expanding and plastically deforming an expandable member;

wherein an outer portion of the wall thickness of the radially expanded and plastically deformed expandable member comprises tensile residual stresses.

51. A structural completion, comprising:

one or more radially expanded and plastically deformed expandable members;

wherein an outer portion of the wall thickness of one or more of the radially expanded and plastically deformed expandable members comprises tensile residual stresses.

52. A method of constructing a structure using an expandable tubular member, comprising:

strain aging the expandable member; and

then radially expanding and plastically deforming the expandable member.

53. A method for manufacturing a tubular member used to complete a wellbore by radially expanding the tubular member at a downhole location in the wellbore comprising: forming a steel alloy comprising a concentration of carbon between approximately 0.002% and 0.08% by weight of the steel alloy.

54. An expandable tubular member fabricated from a steel alloy having a concentration of carbon between approximately 0.002% and 0.08% by weight of the steel alloy.

55. A method of radially expanding and plastically deforming a tubular member using an expansion device, comprising:

quenching and tempering the tubular member;

positioning the tubular member within a preexisting structure; and

radially expanding and plastically deforming the tubular member.

56. A radially expandable and plastically deformable tubular member, comprising:

a yield strength ranging from about 76.8 ksi to 88.8 ksi;

a ratio of the yield strength to a tensile strength of the tubular member ranging from about 0.82 to 0.86;

a longitudinal elongation of the tubular member prior to failure ranging from about 14.8% to 22.0%;

a wall reduction of the tubular member prior to failure ranging from about 32% to 44.0%;

a width thickness reduction of the tubular member prior to failure ranges from about 41.0% to 45%; and

an anisotropy of the tubular member ranges from about 0.65 to 1.03.

57. A radially expandable and plastically deformable tubular member, comprising:

a yield strength ranging from about 40.0 ksi to 100.0 ksi;

a ratio of the yield strength to a tensile strength of the tubular member ranging from about 0.40 to 0.85;

a longitudinal elongation of the tubular member prior to failure ranging from at least about 22.0 to 35.0%;

a width reduction of the tubular member prior to failure ranging from at least about 30.0% to 45.0%;

a wall thickness reduction of the tubular member prior to failure ranges from at least about 30.0% to 45.0%; and

an anisotropy of the tubular member ranges from at least about 0.65 to 1.50.

58. A method of manufacturing a tubular member, comprising:

fabricating a tubular member having one or more intermediate characteristics;

positioning the tubular member within a preexisting structure;

radially expanding and plastically deforming the tubular member within the preexisting structure;

and

baking the tubular member within the preexisting structure to convert one or more of the intermediate characteristics to final characteristics.

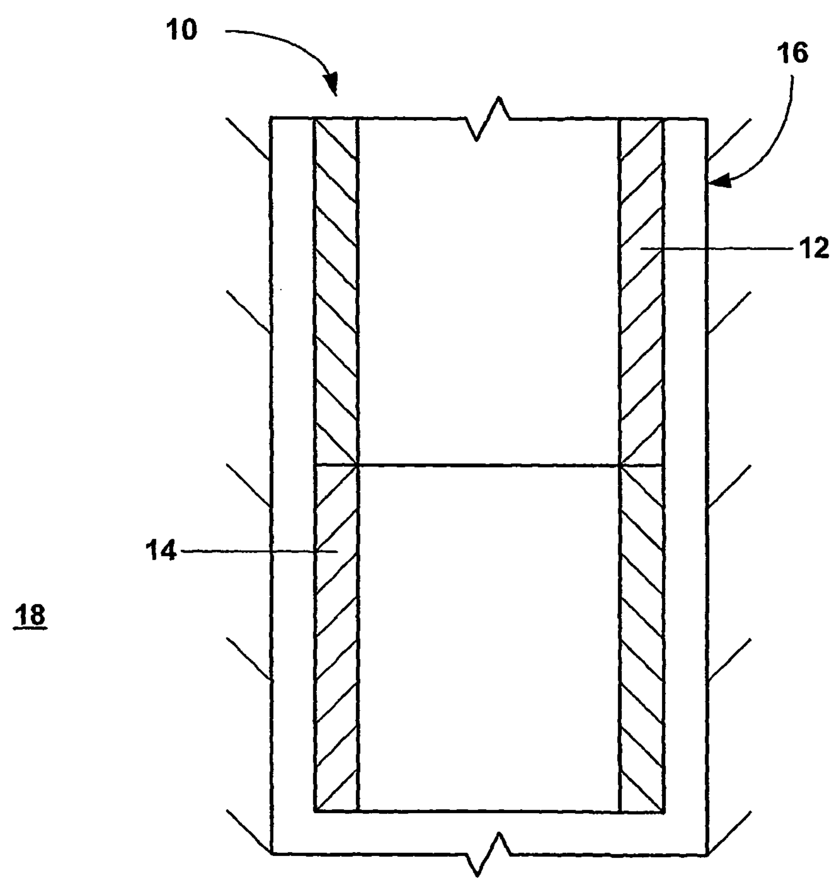



FIG. 1

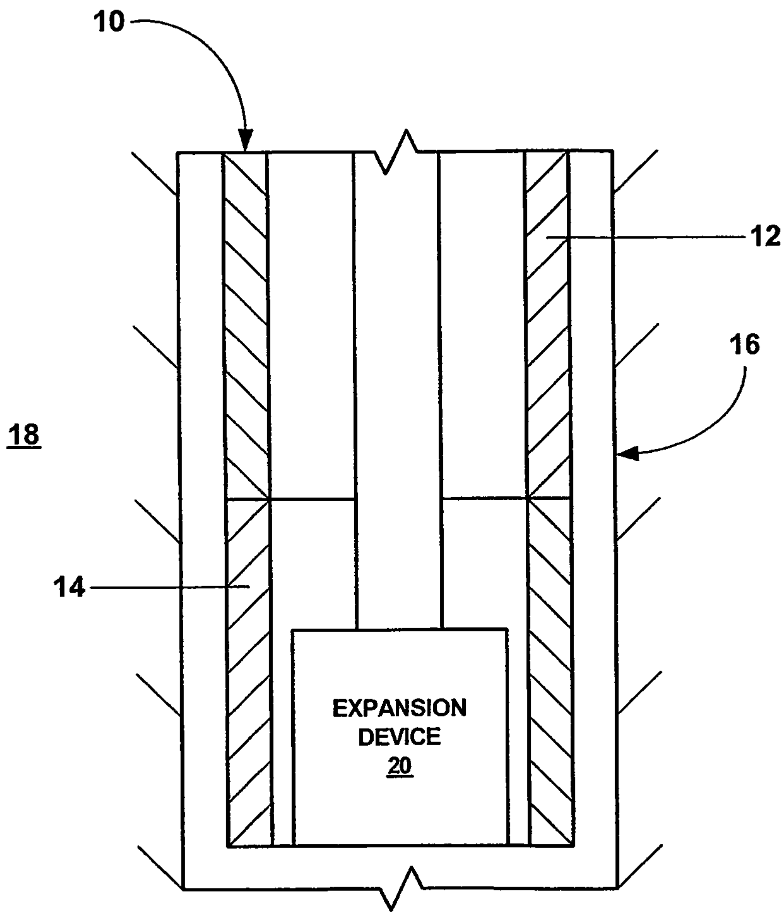



FIG. 2

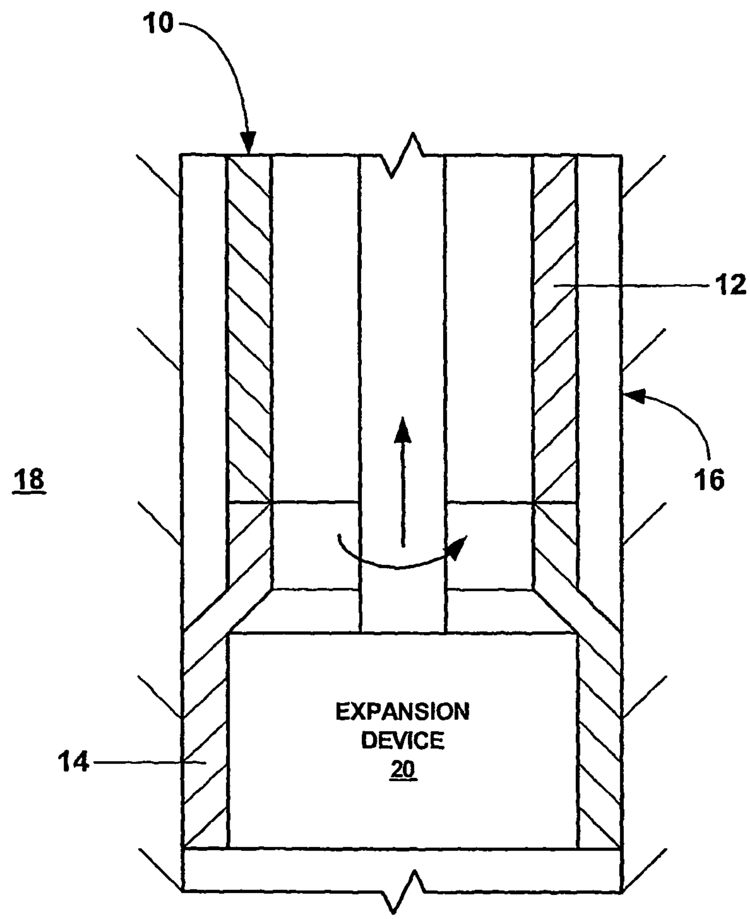



FIG. 3

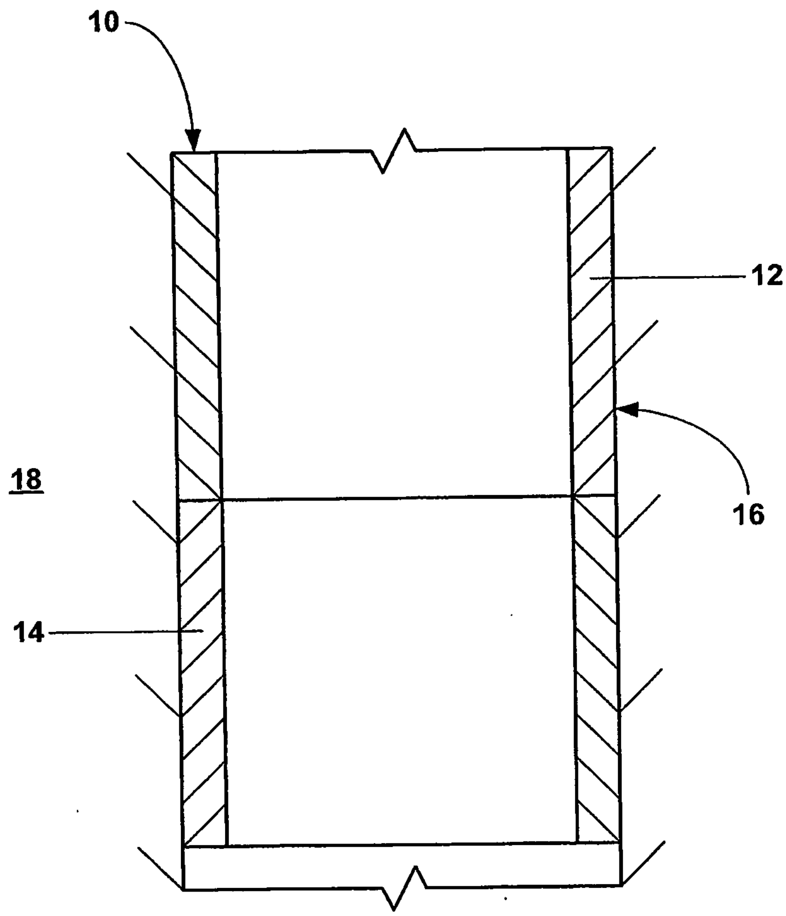



FIG. 4

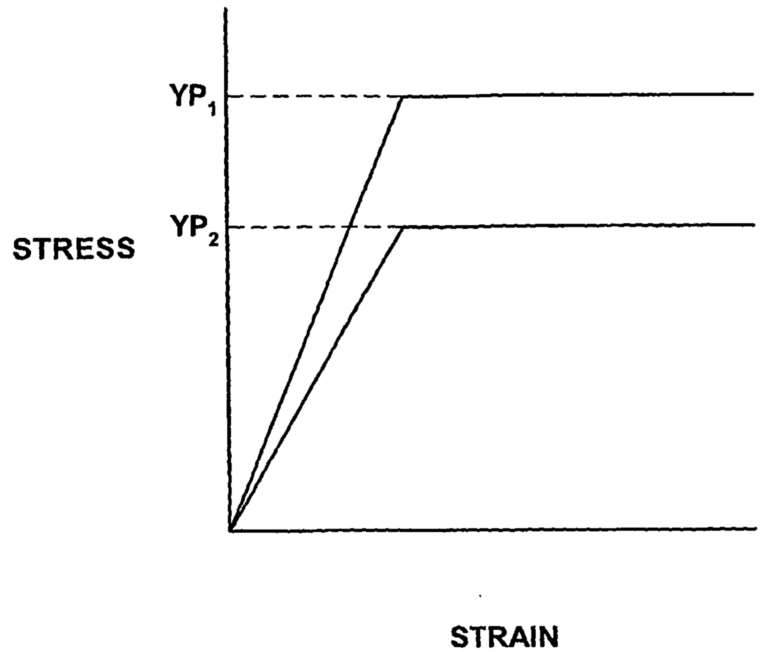

YP1
YP2
STRESS
STRAIN

FIG. 5

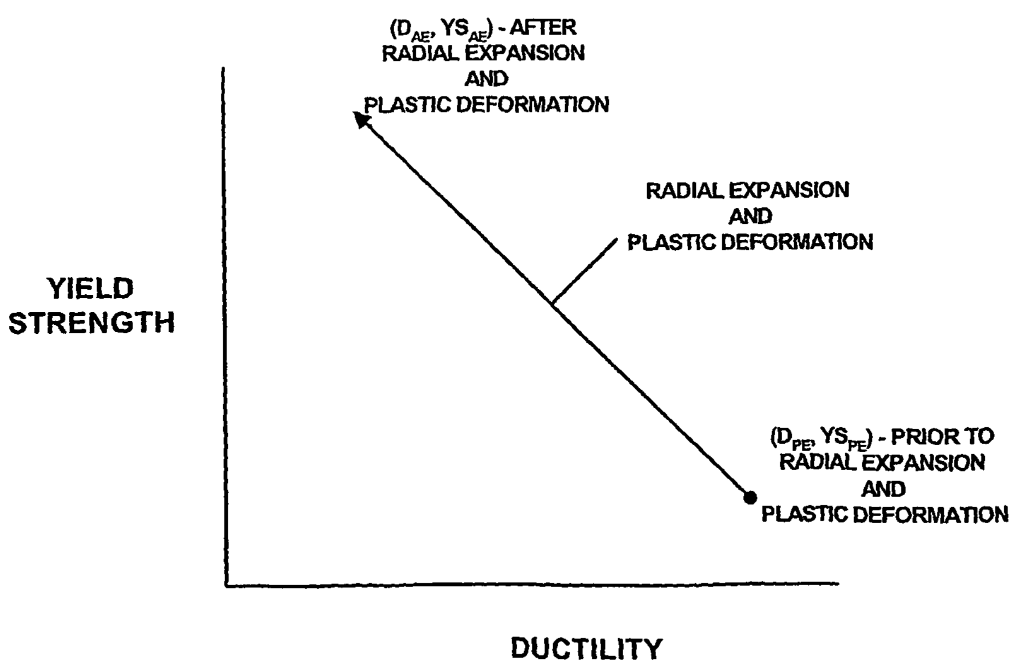

(D_AE, YS_AE) - AFTER RADIAL EXPANSION AND PLASTIC DEFORMATION
RADIAL EXPANSION AND PLASTIC DEFORMATION
YIELD STRENGTH
(D_PE, YS_PE) - PRIOR TO RADIAL EXPANSION AND PLASTIC DEFORMATION
DUCTILITY

FIG. 6

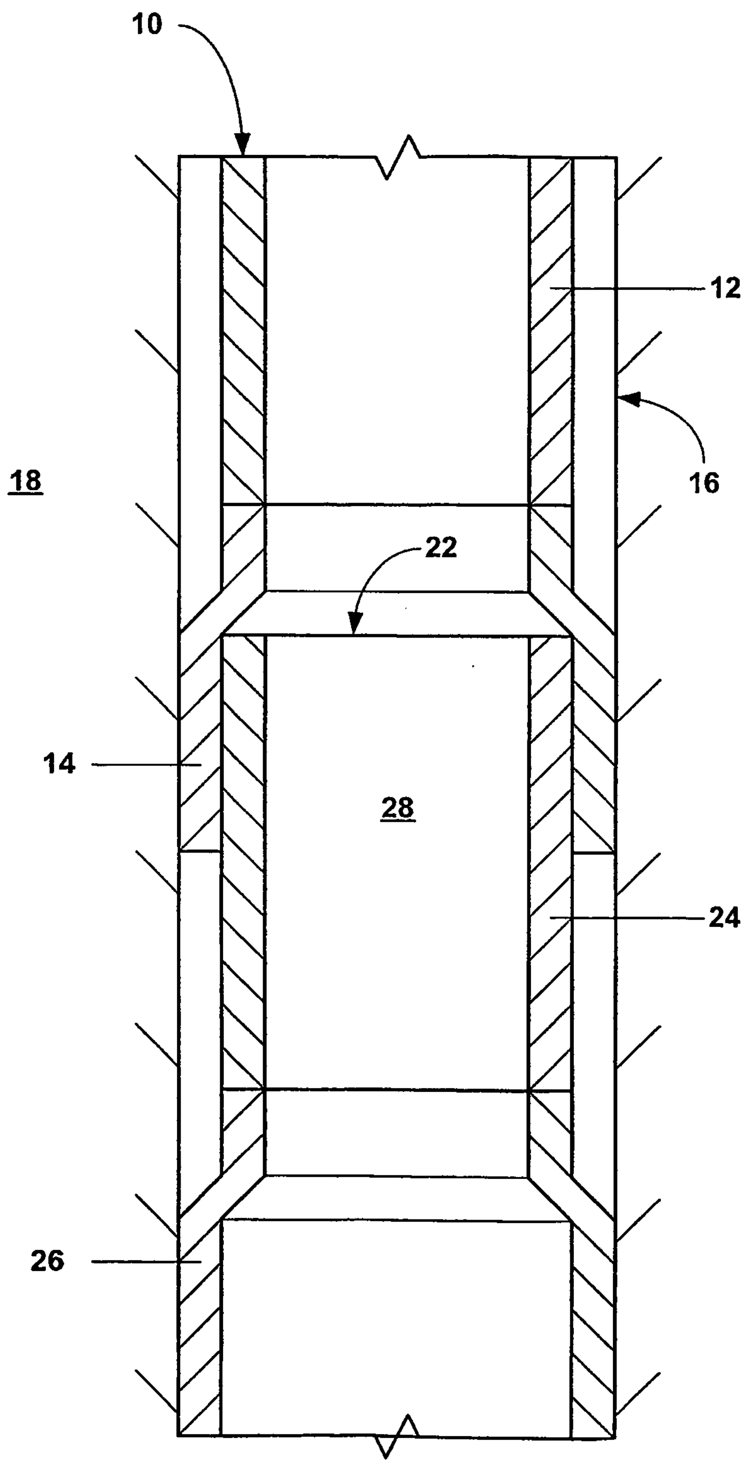



FIG. 7

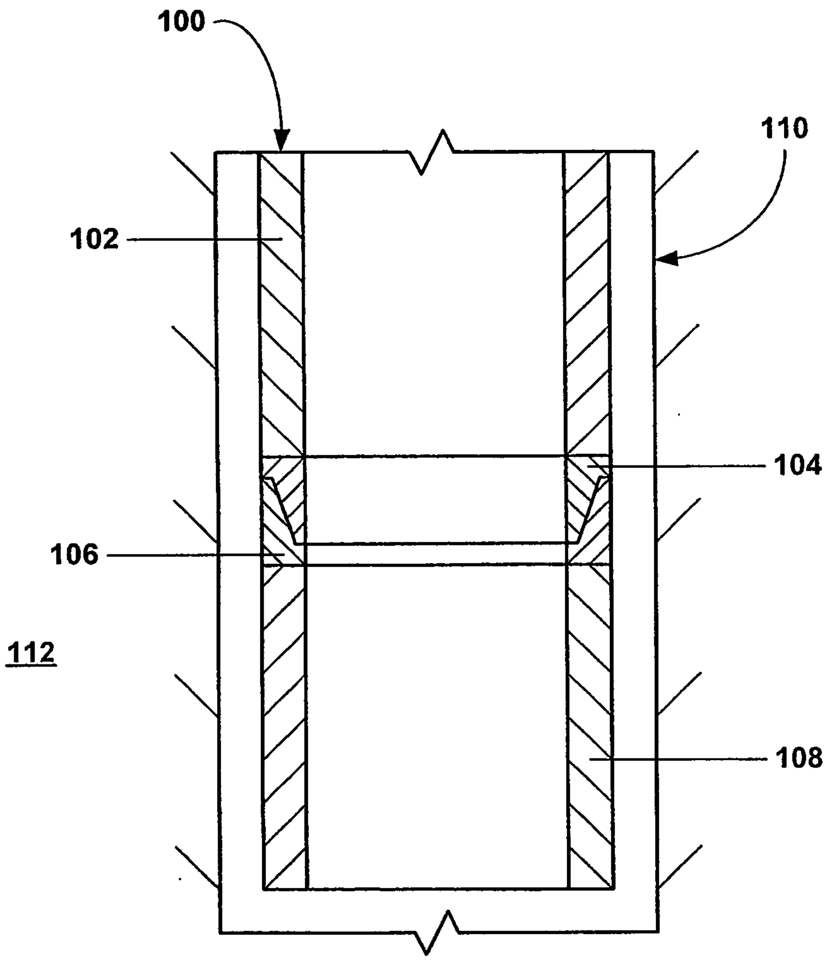



FIG. 8

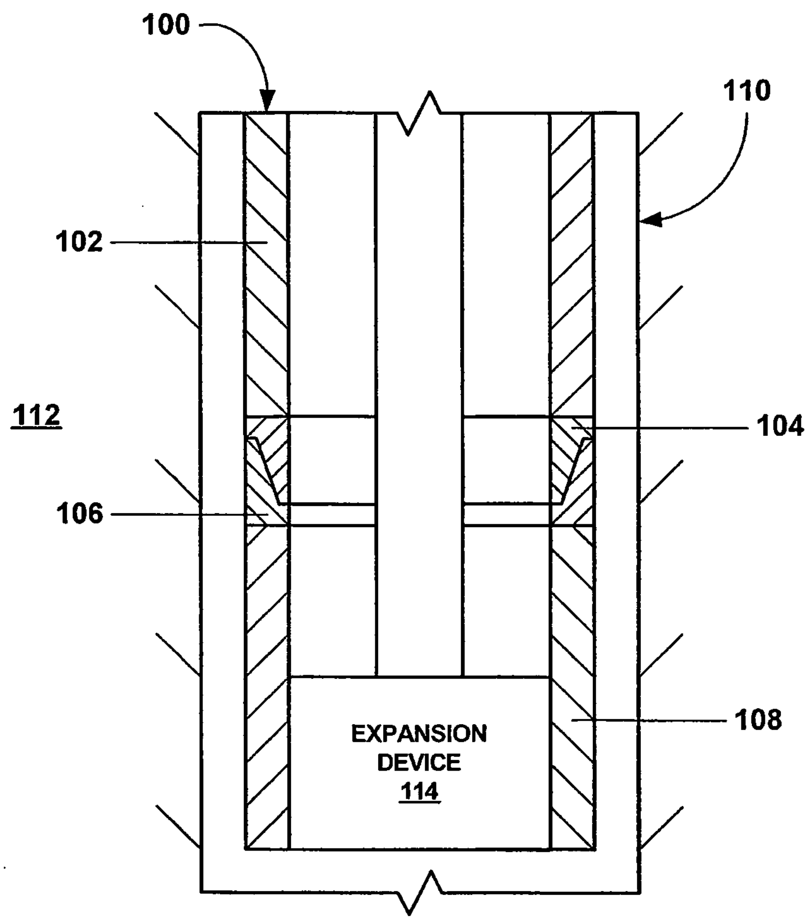



FIG. 9

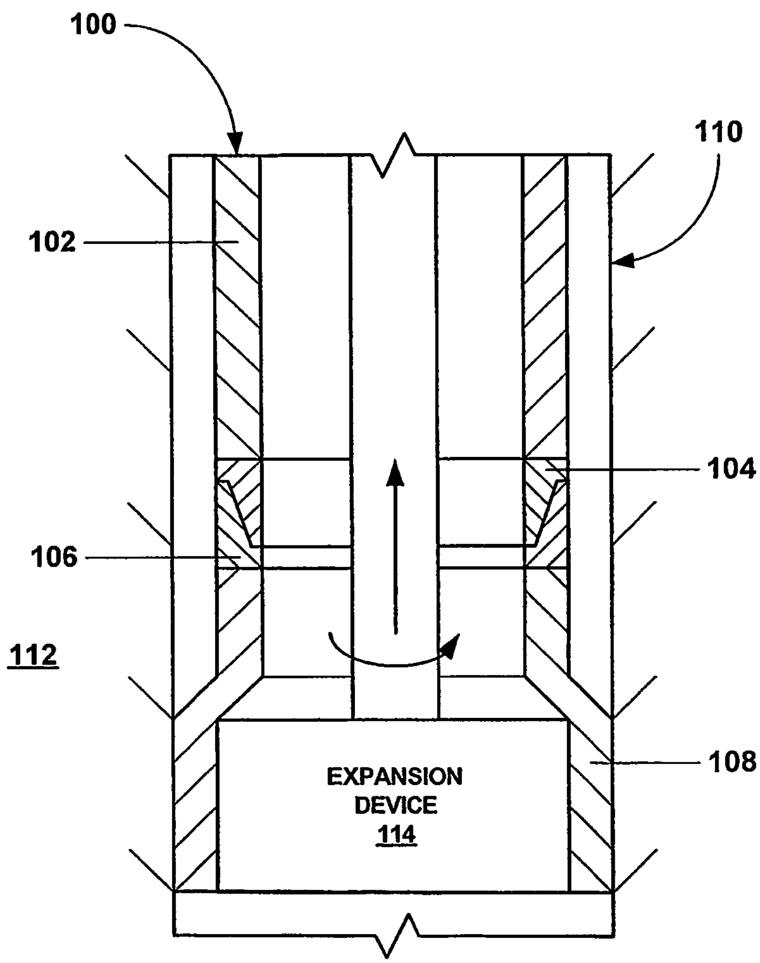



FIG. 10

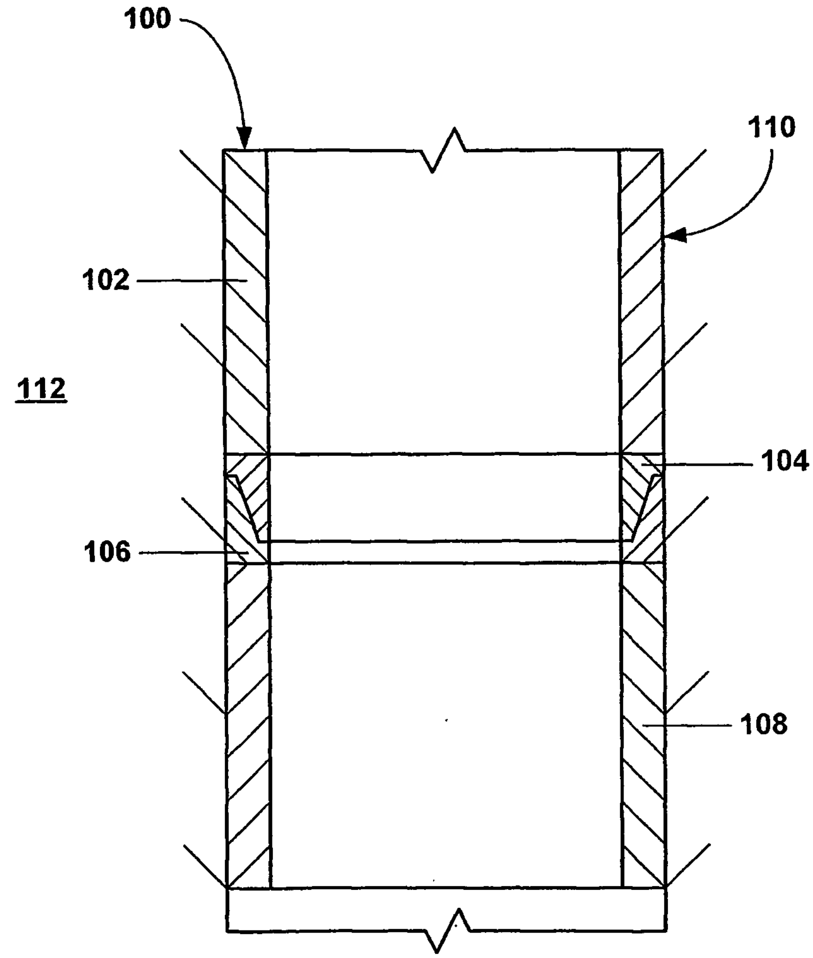



FIG. 11

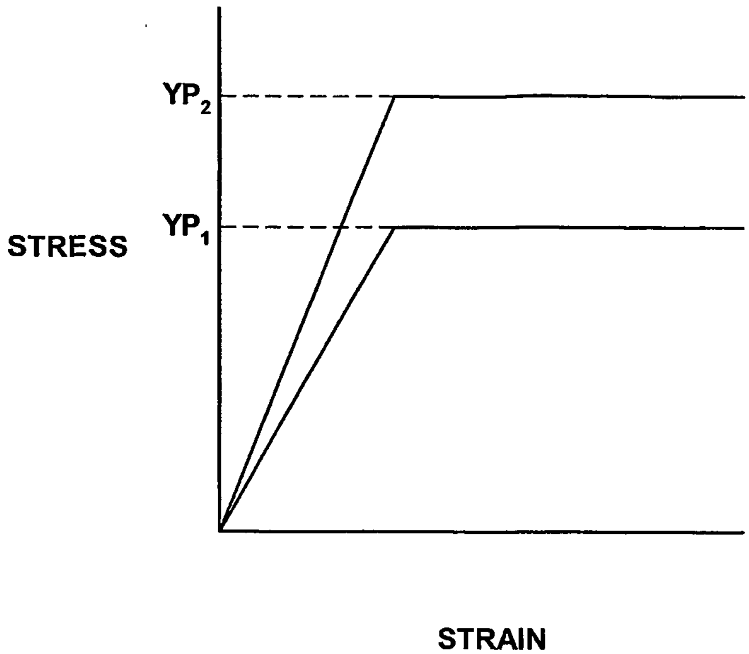

STRESS
YP2
YP1
STRAIN

FIG. 12

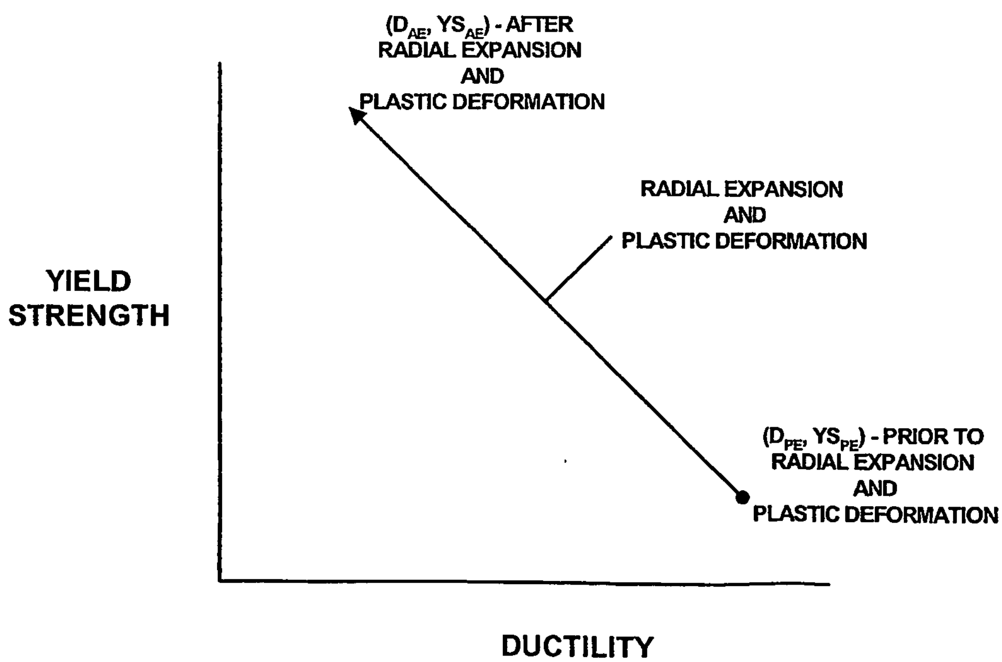

(DAE, YSAE) - AFTER RADIAL EXPANSION AND PLASTIC DEFORMATION
RADIAL EXPANSION AND PLASTIC DEFORMATION
YIELD STRENGTH
(DPE, YSPE) - PRIOR TO RADIAL EXPANSION AND PLASTIC DEFORMATION
DUCTILITY

FIG. 13

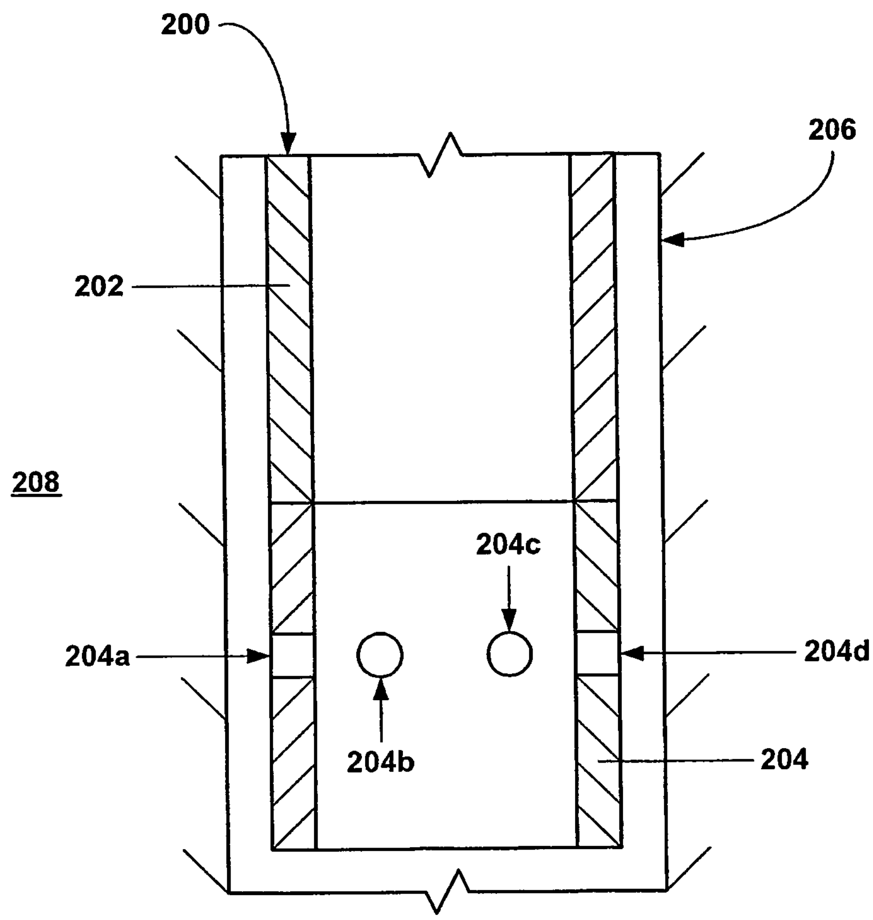



FIG. 14

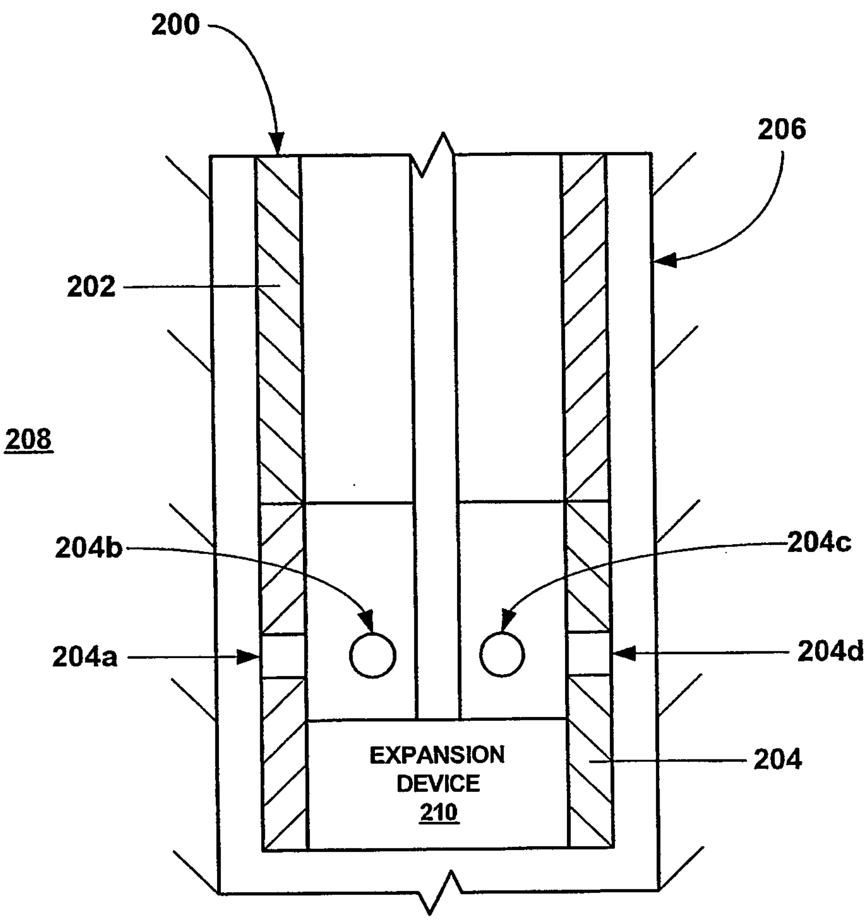



FIG. 15

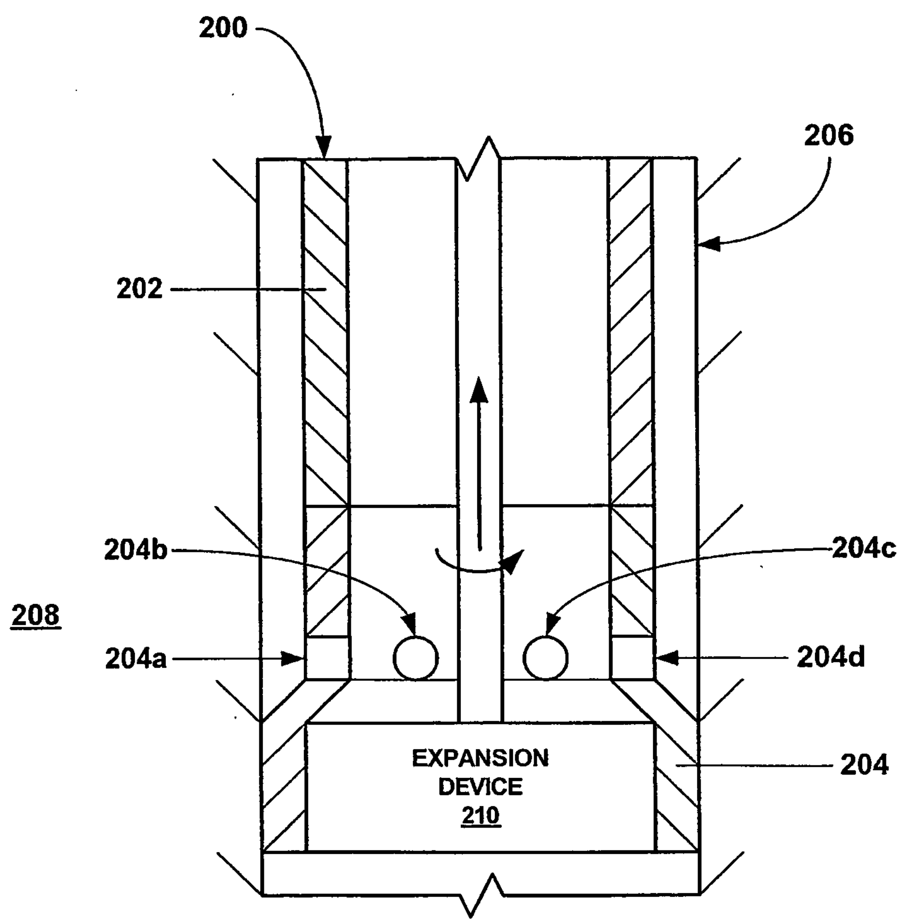



FIG. 16

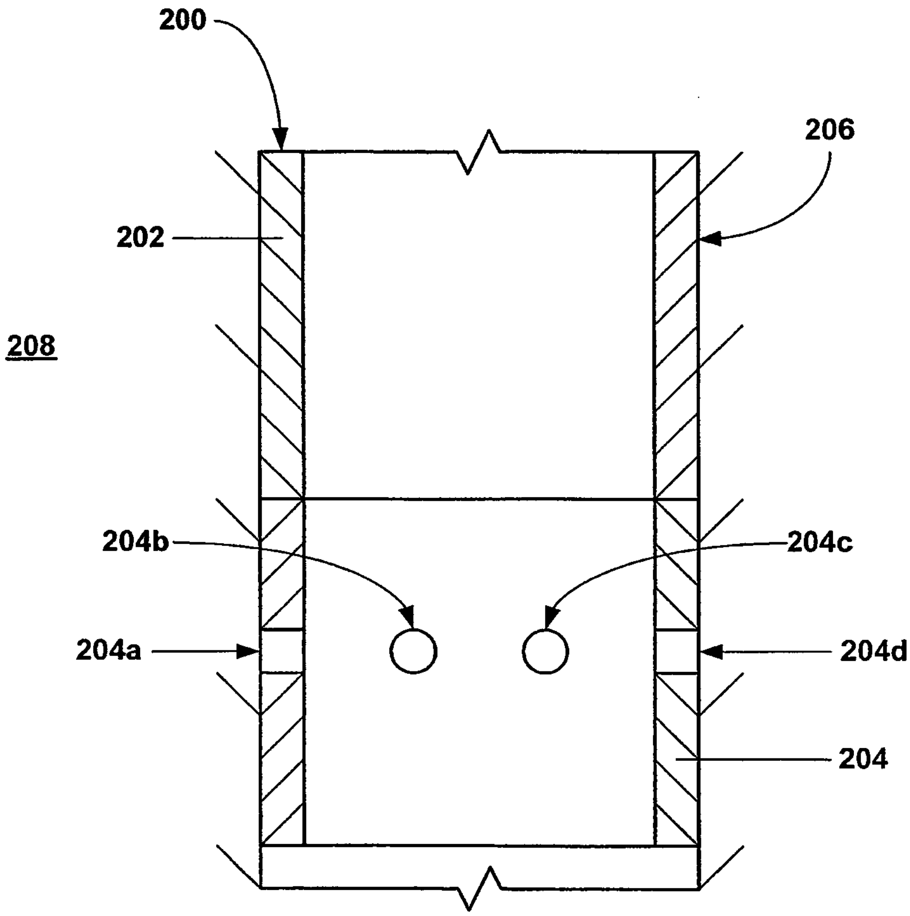



FIG. 17

300

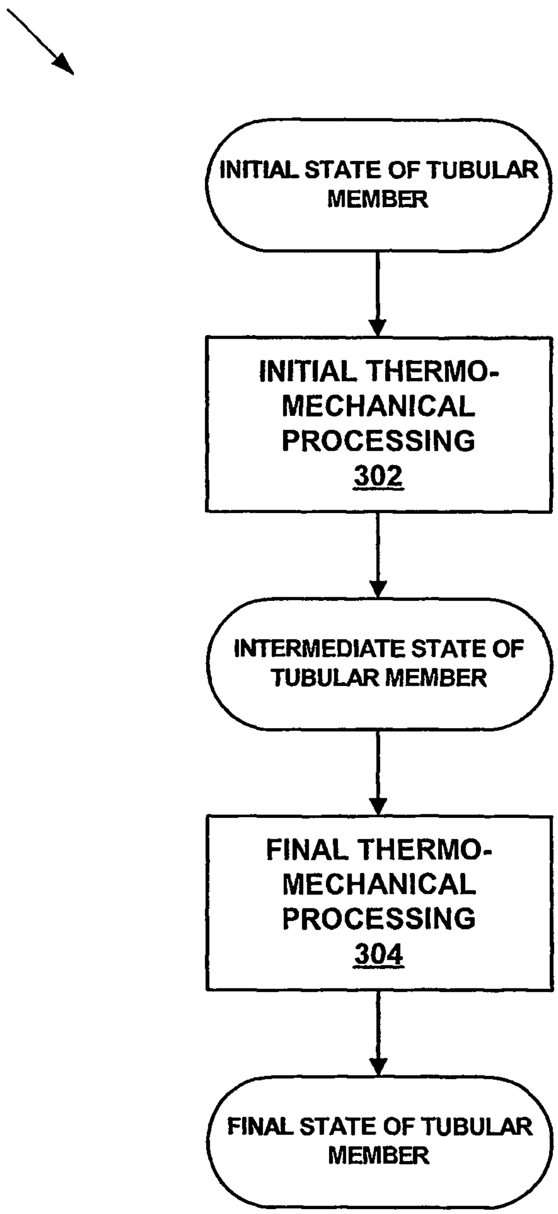

INITIAL STATE OF TUBULAR MEMBER
INITIAL THERMO-MECHANICAL PROCESSING 302
INTERMEDIATE STATE OF TUBULAR MEMBER
FINAL THERMO-MECHANICAL PROCESSING 304
FINAL STATE OF TUBULAR MEMBER

Fig. 18

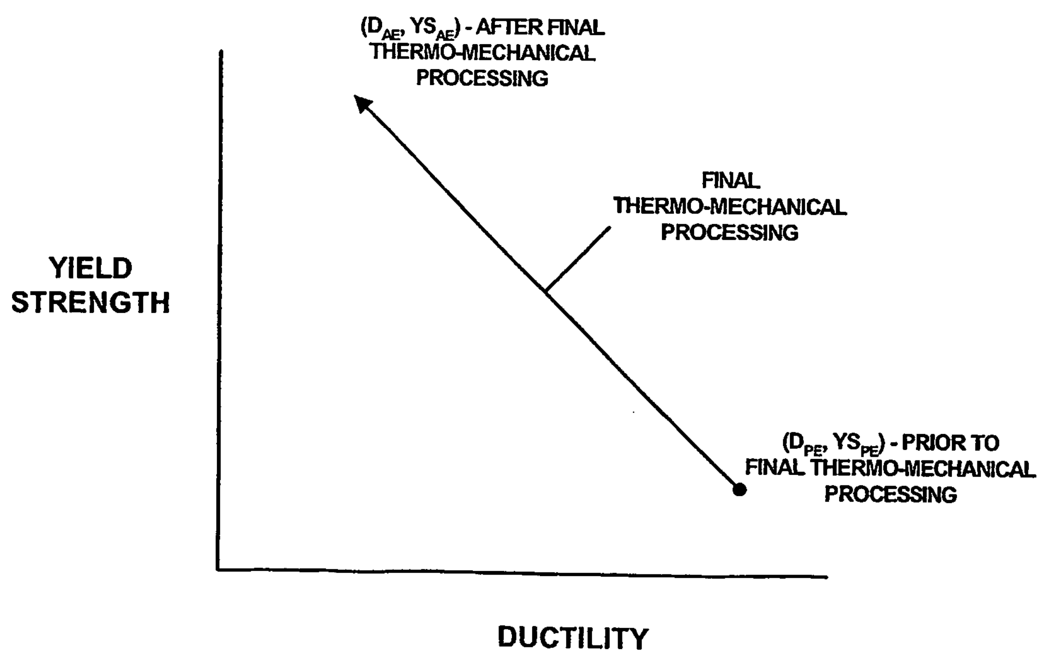

($D_{AE}$, $YS_{AE}$) - AFTER FINAL THERMO-MECHANICAL PROCESSING
FINAL THERMO-MECHANICAL PROCESSING
YIELD STRENGTH
($D_{PE}$, $YS_{PE}$) - PRIOR TO FINAL THERMO-MECHANICAL PROCESSING
DUCTILITY

FIG. 19

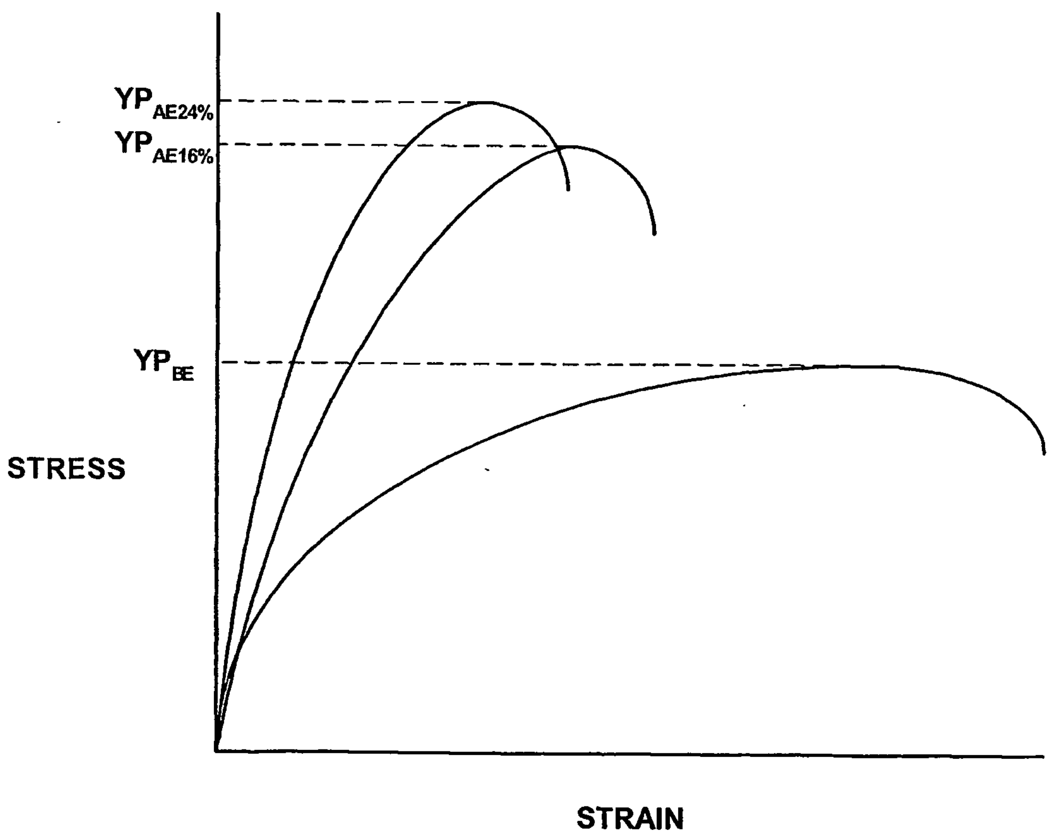



FIG. 20

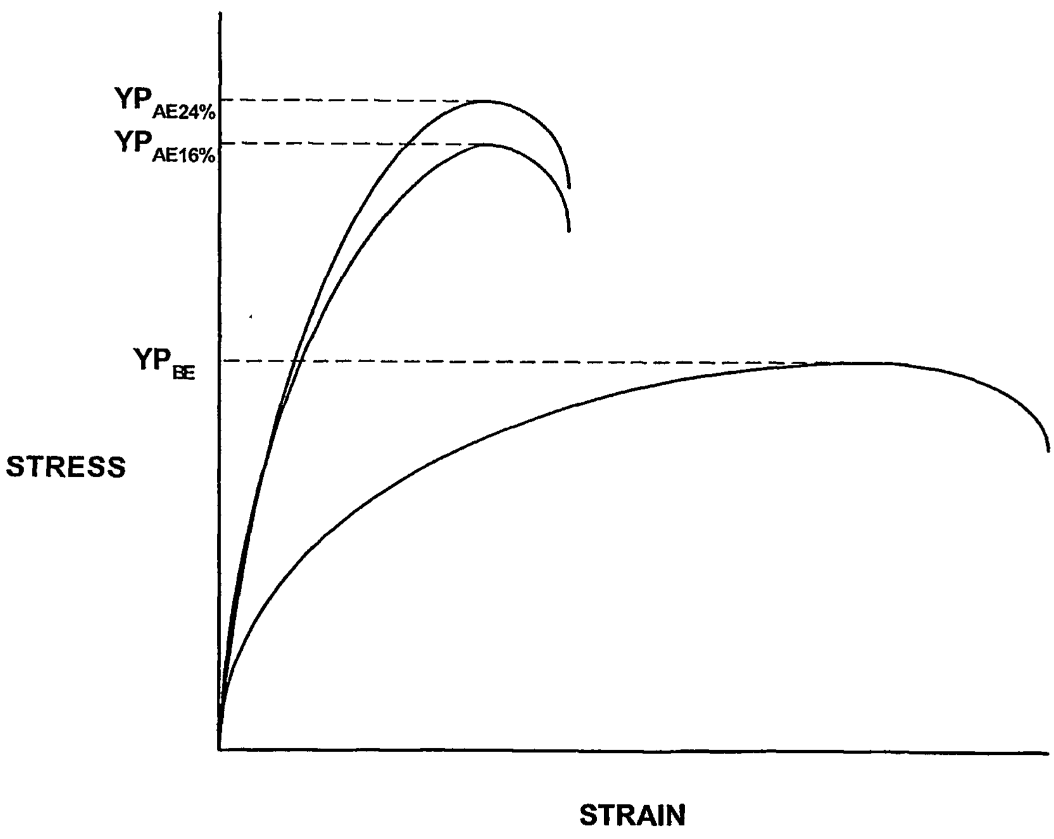
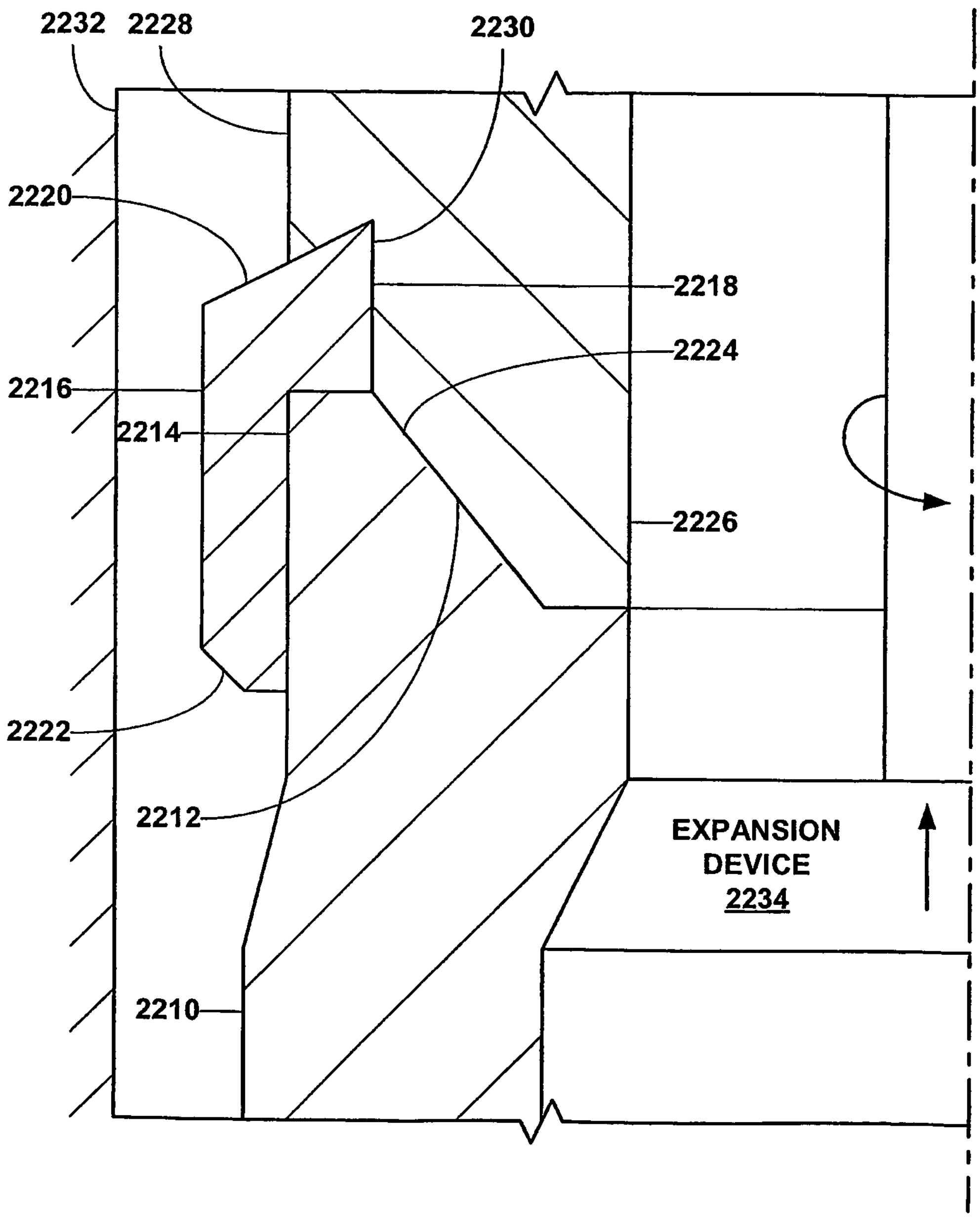



FIG. 21


2232
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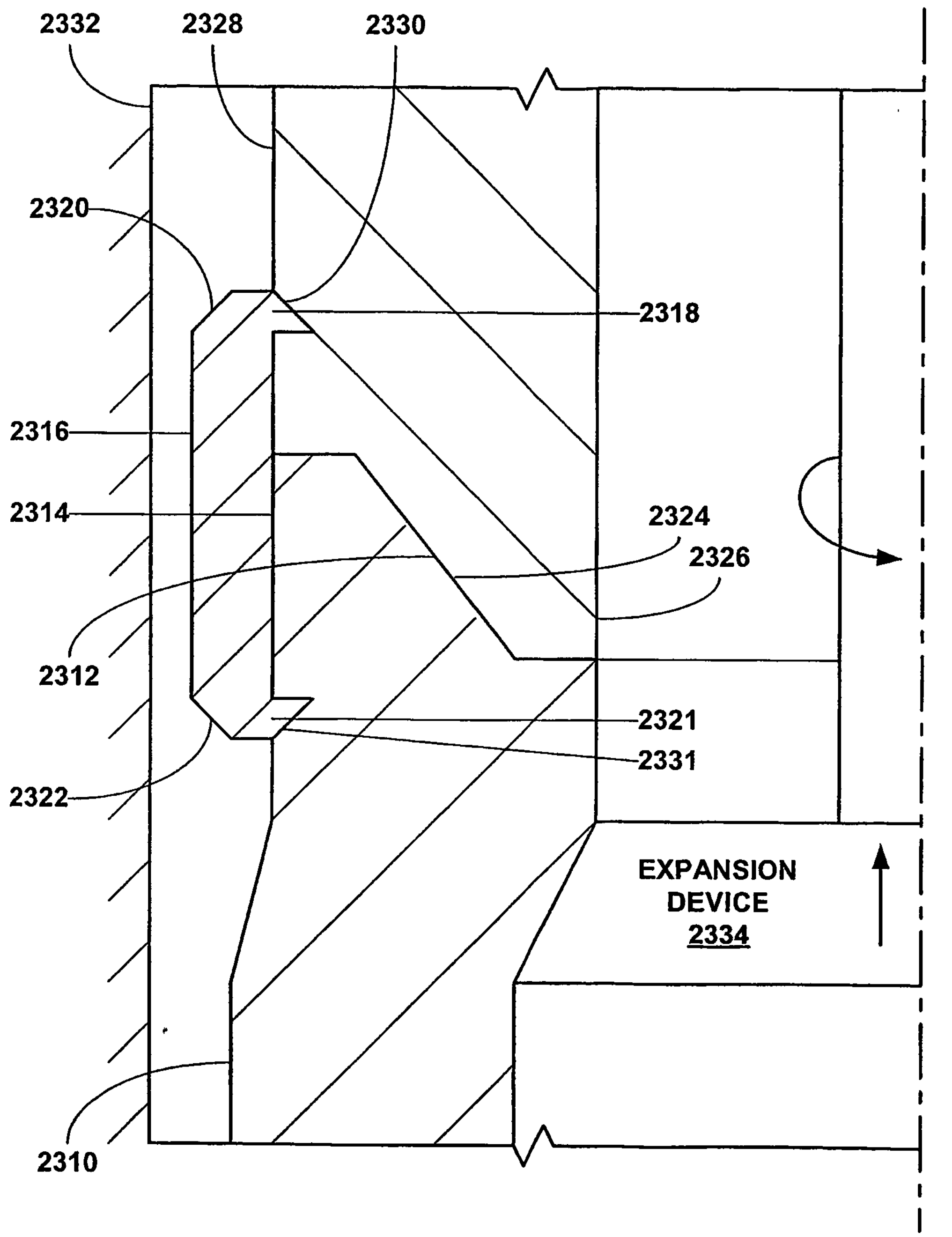
2222
2212
EXPANSION
DEVICE
2234
2210

FIG. 22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2321
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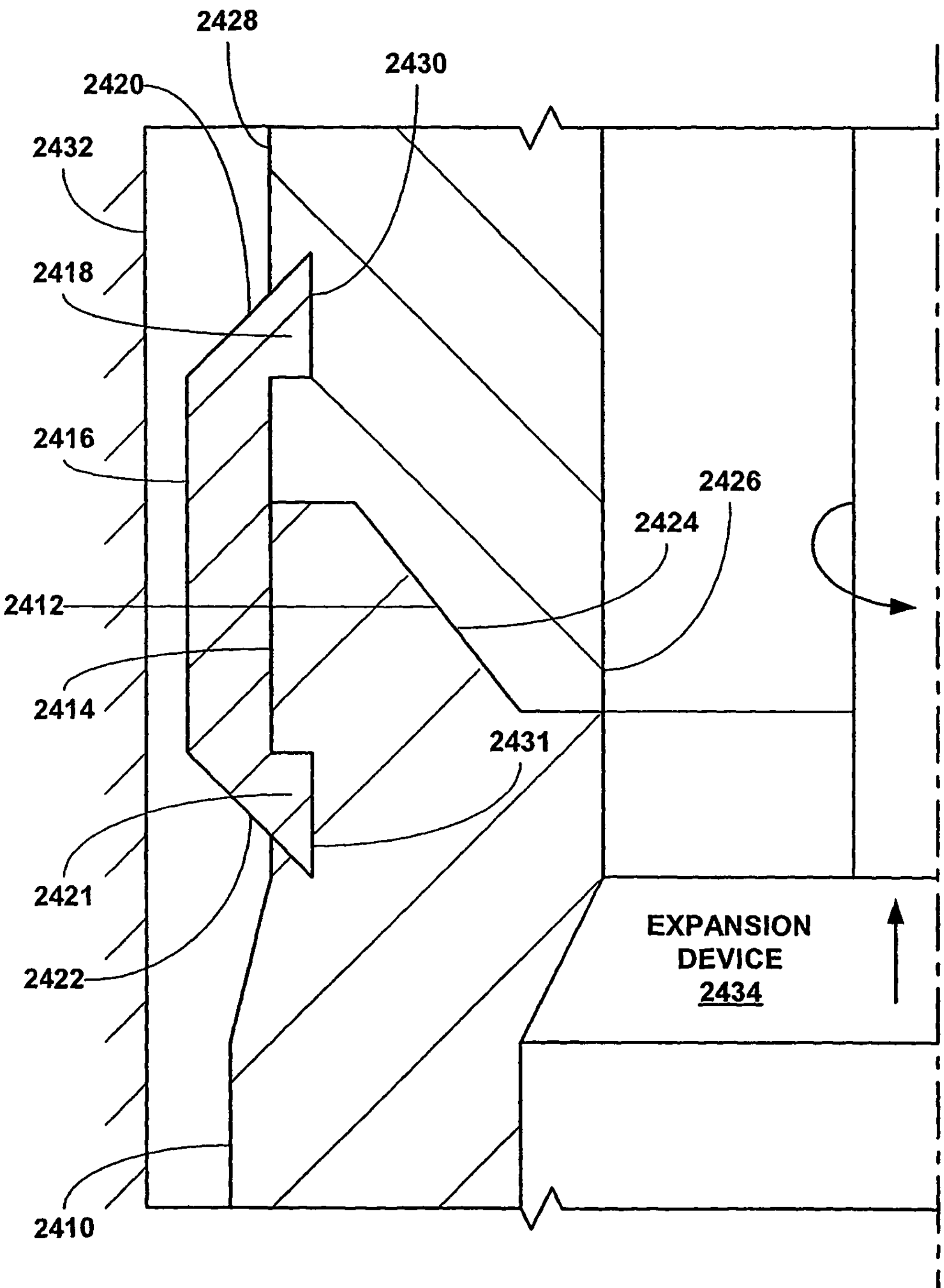
2322
EXPANSION
DEVICE
2334
2310

FIG. 23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EXPANSION
DEVICE
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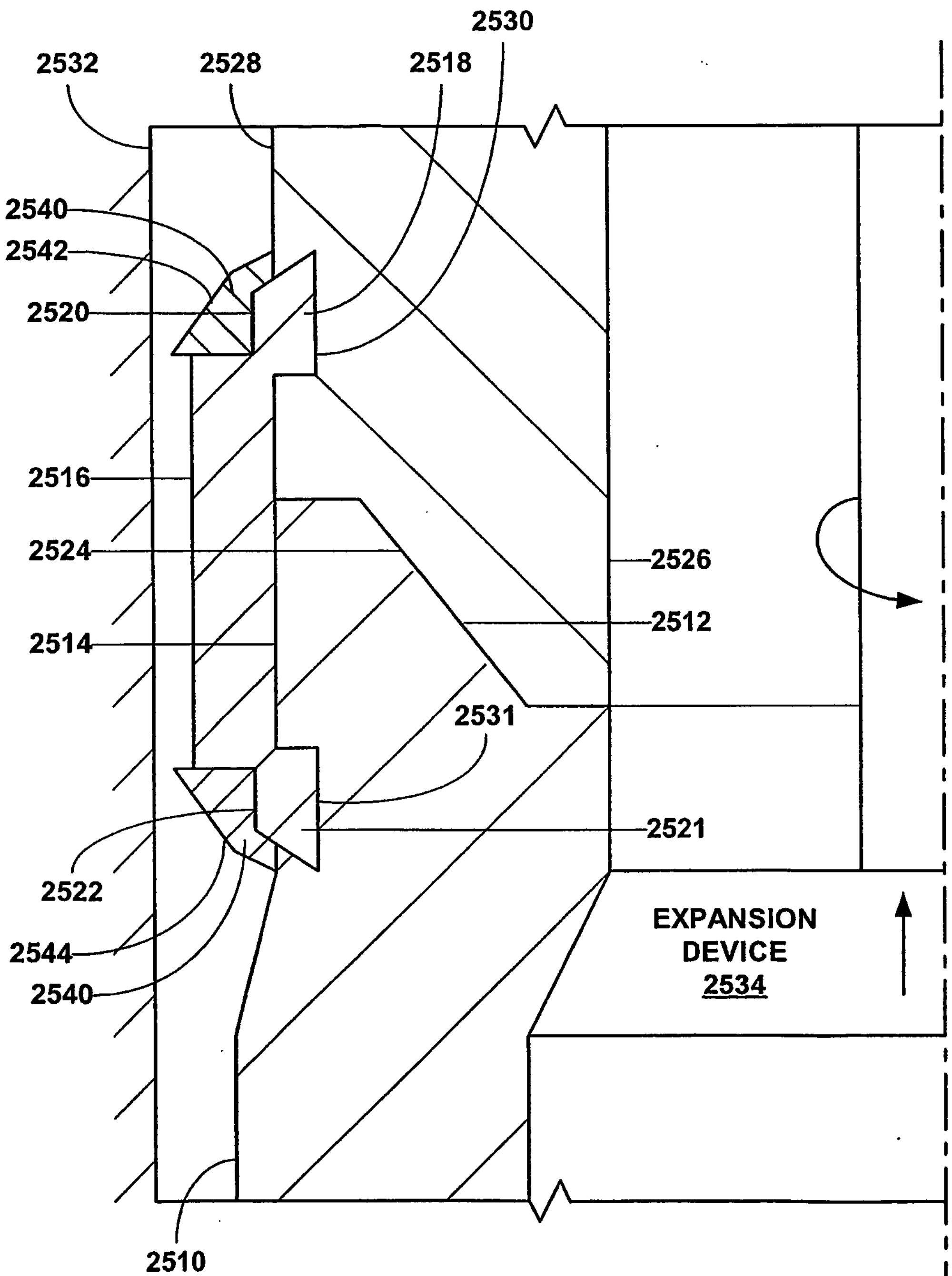
FIG. 24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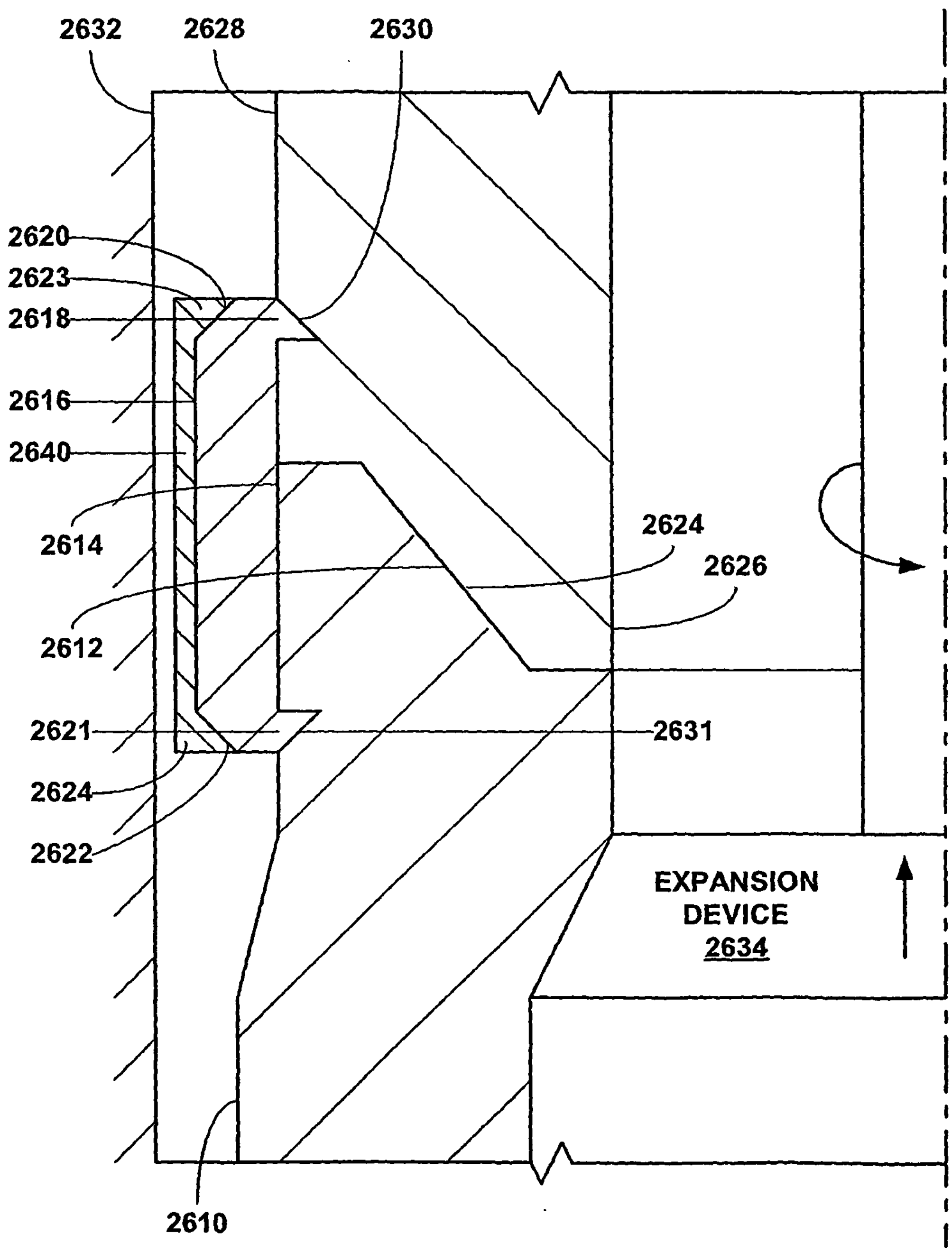
2544
2540
EXPANSION
DEVICE
2534
2510

FIG. 25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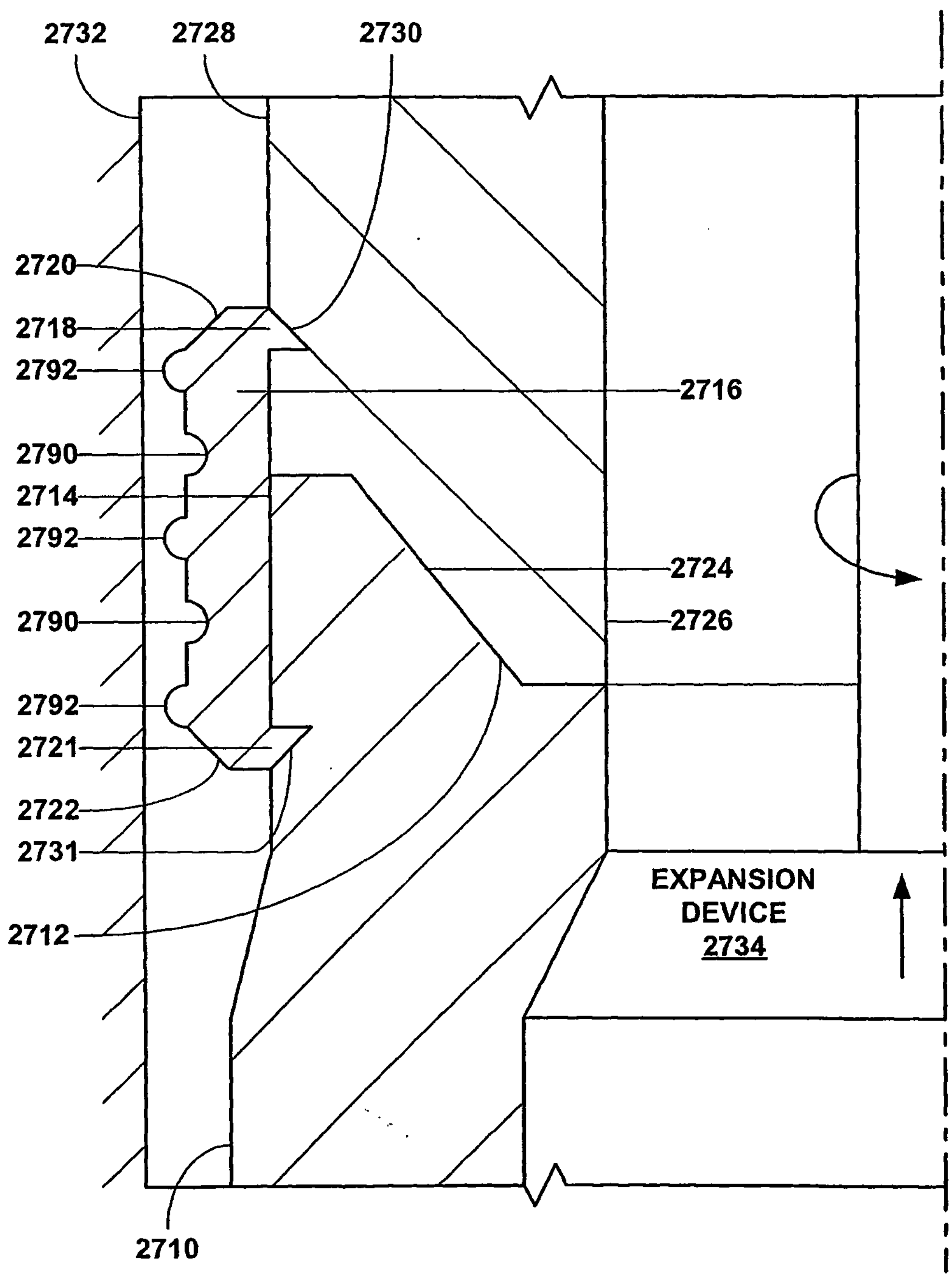
2622
EXPANSION
DEVICE
2634
2610

FIG. 26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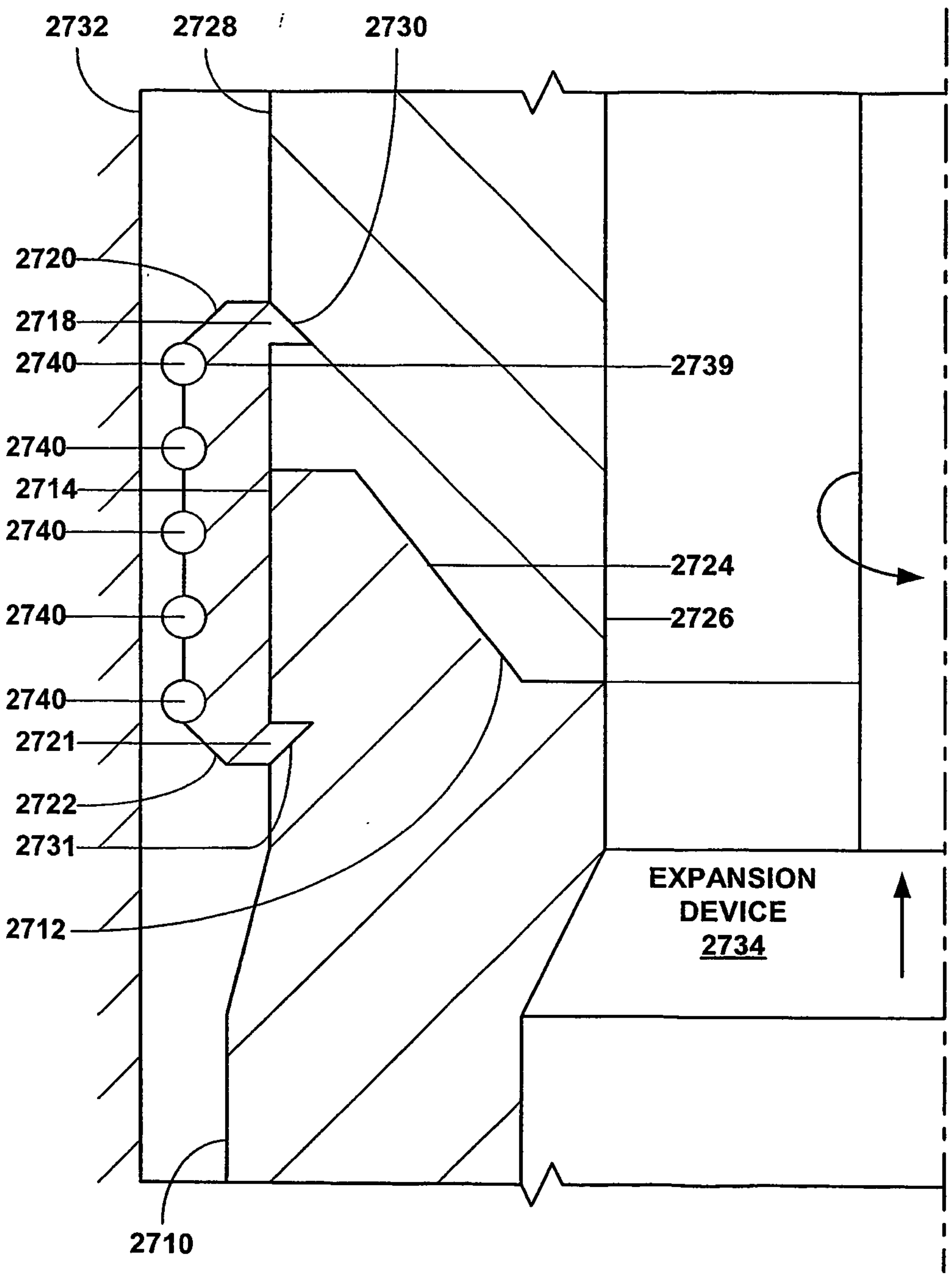
2792
2721
2722
2731
2712
EXPANSION
DEVICE
2734
2710

FIG. 27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2731
2712
EXPANSION
DEVICE
2734
2710

FIG. 28

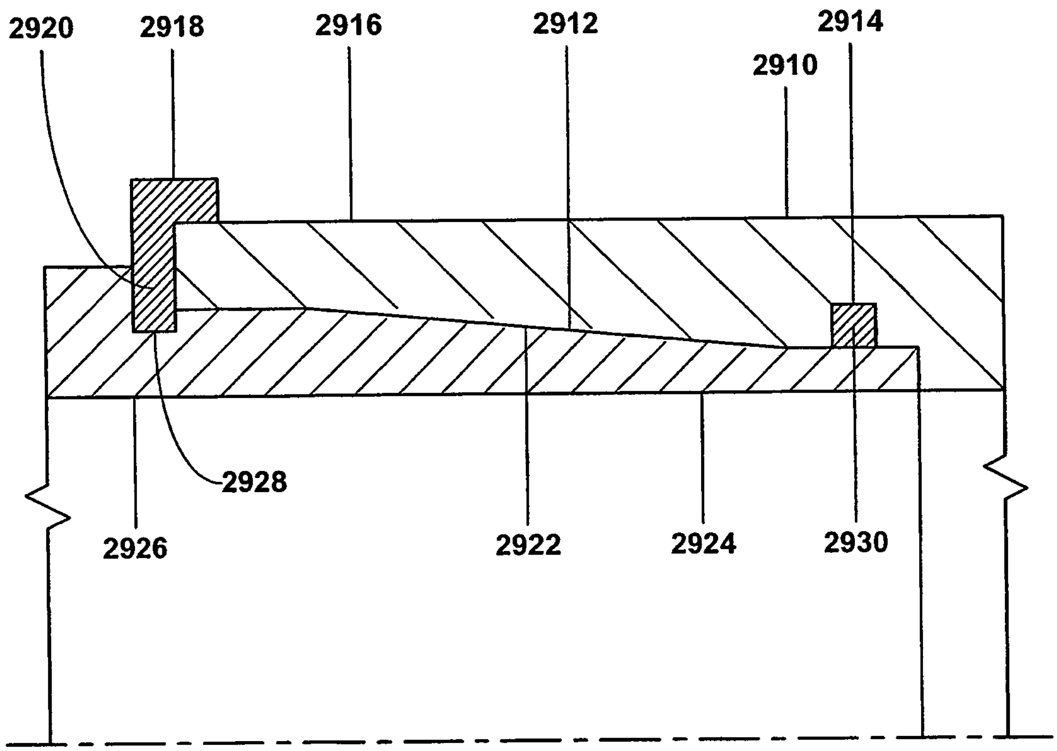



FIG. 29

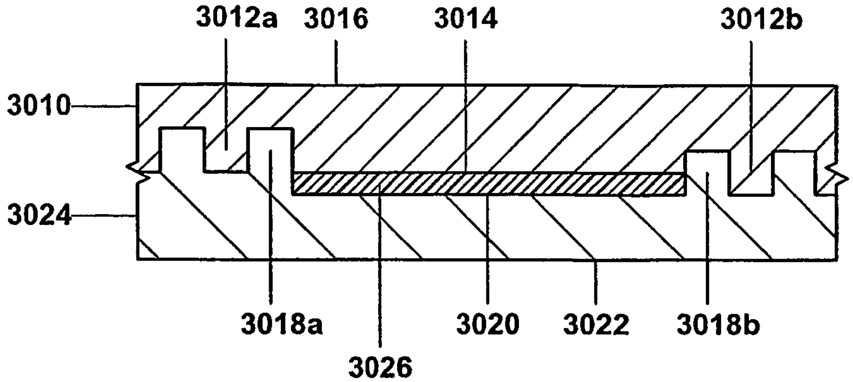



FIG. 30a

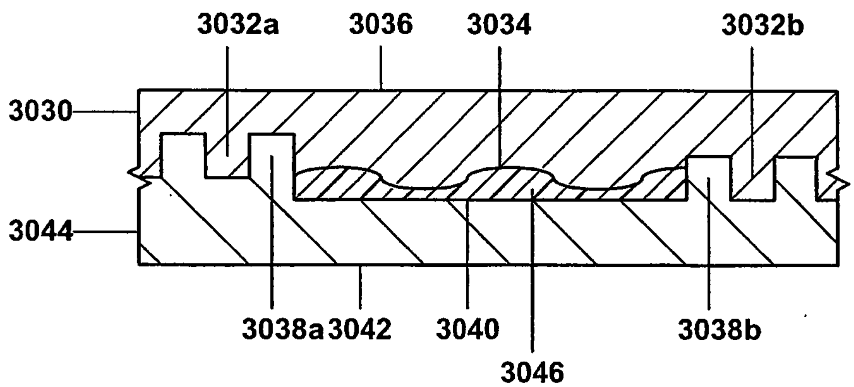



FIG. 30b

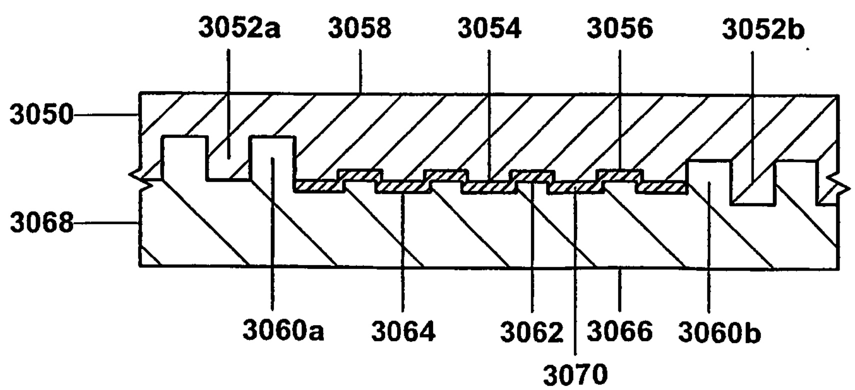
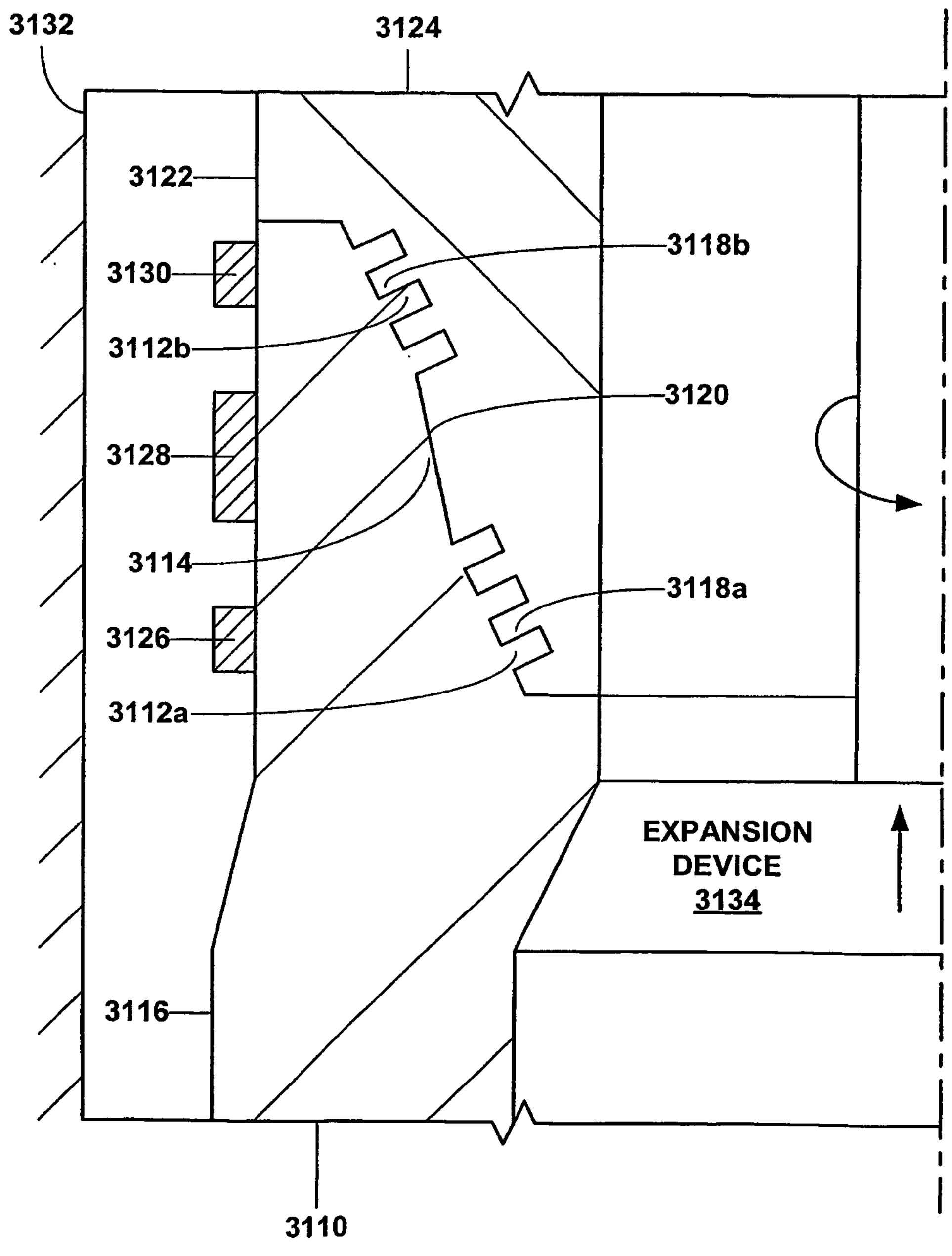



FIG. 30c


3132
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3112b
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3128
3114
3118a
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3112a
EXPANSION
DEVICE
3134
3116
3110

FIG. 31

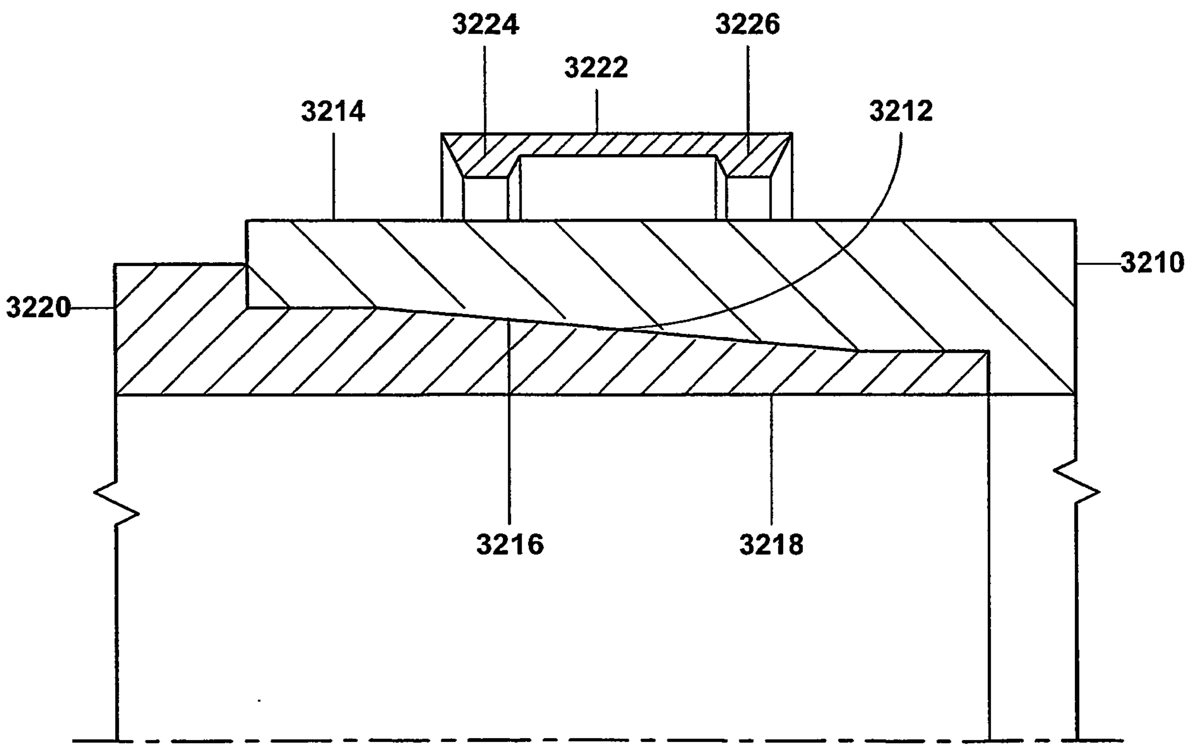



FIG. 32a

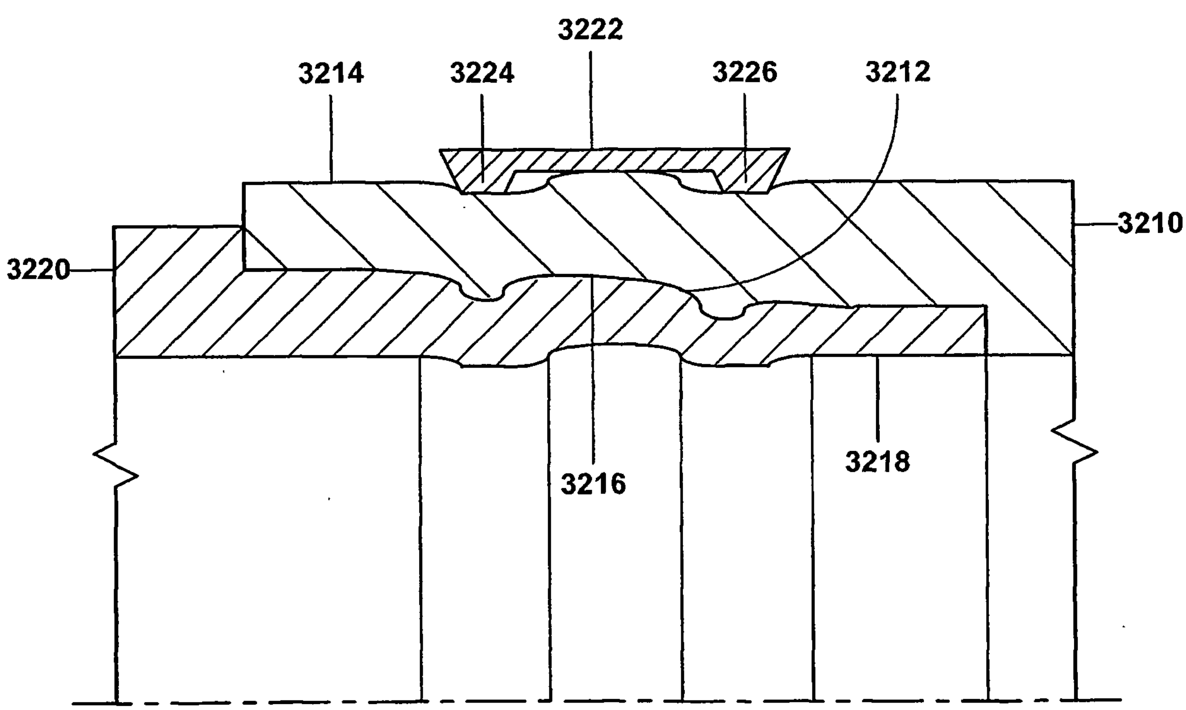
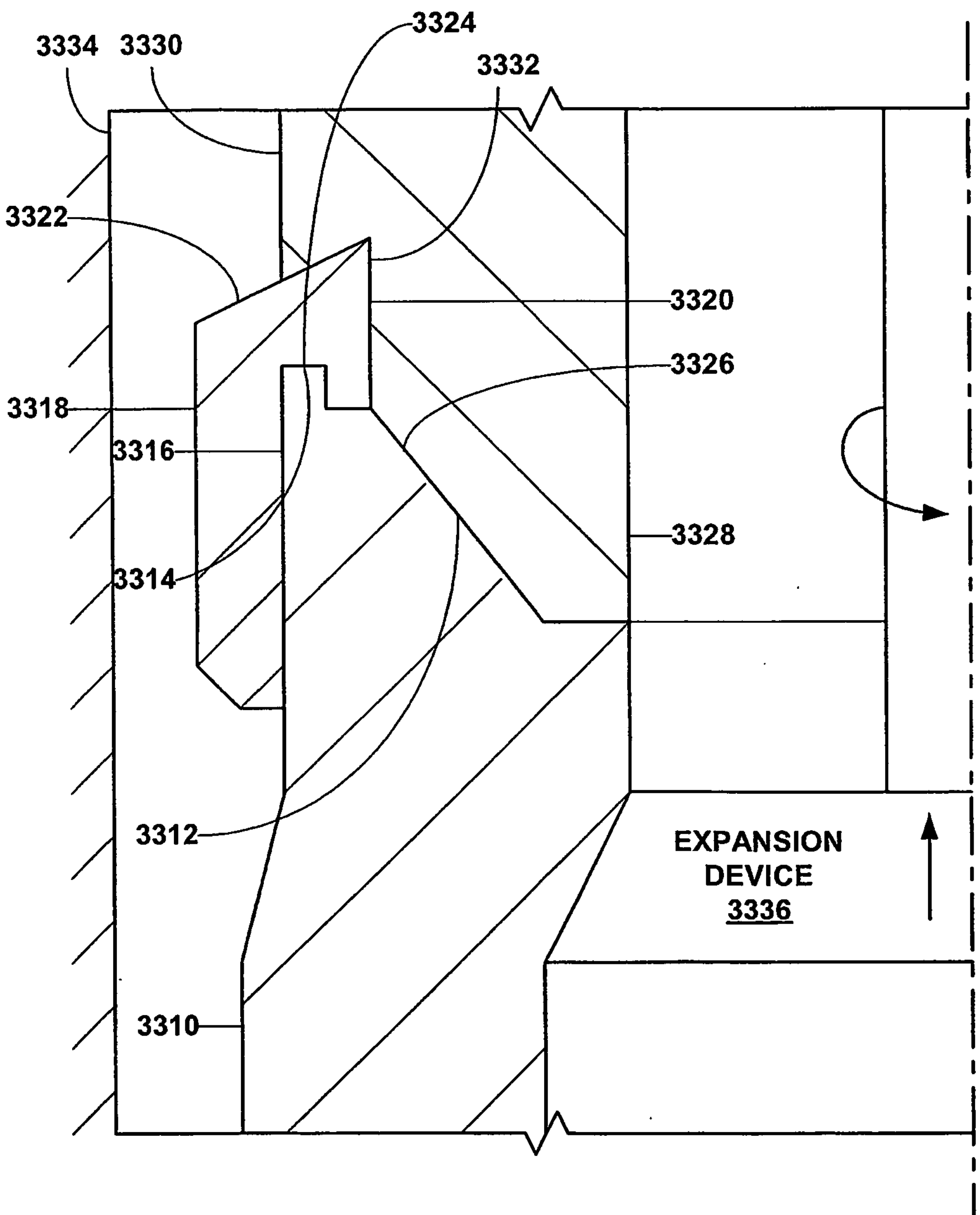



FIG. 32b


3334
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3312
EXPANSION
DEVICE
3336
3310

FIG. 33

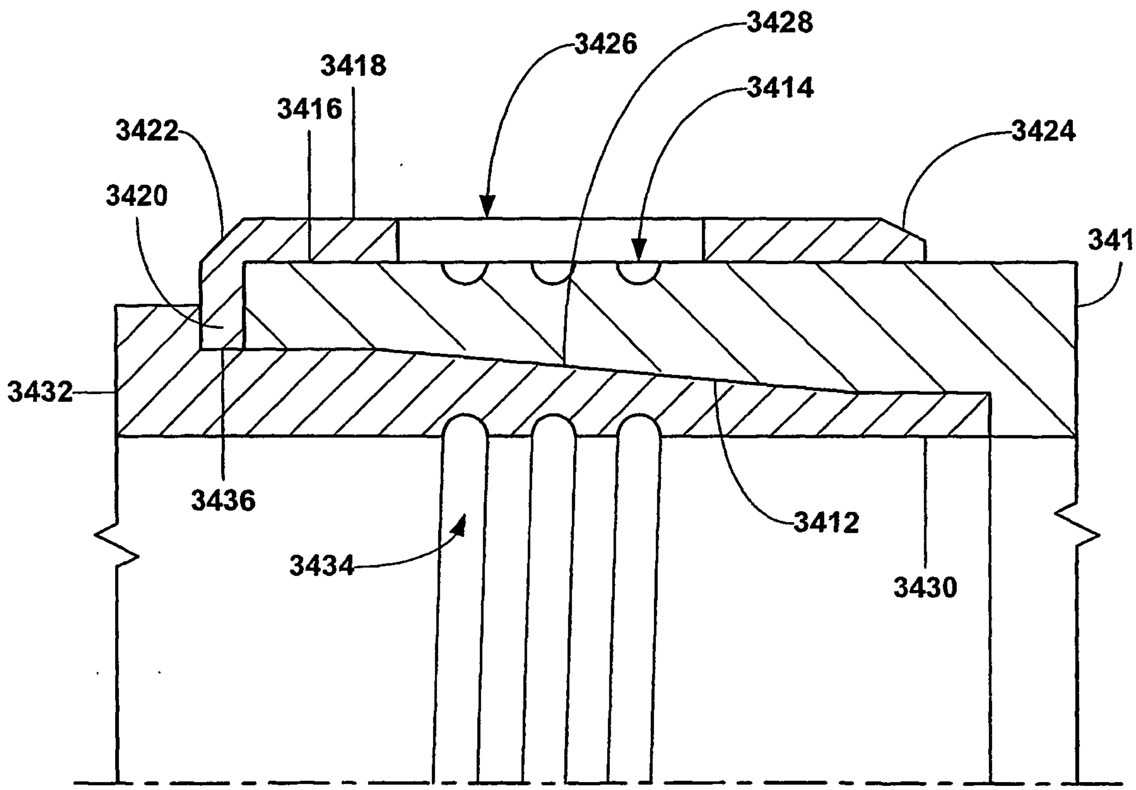
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FIG. 34a

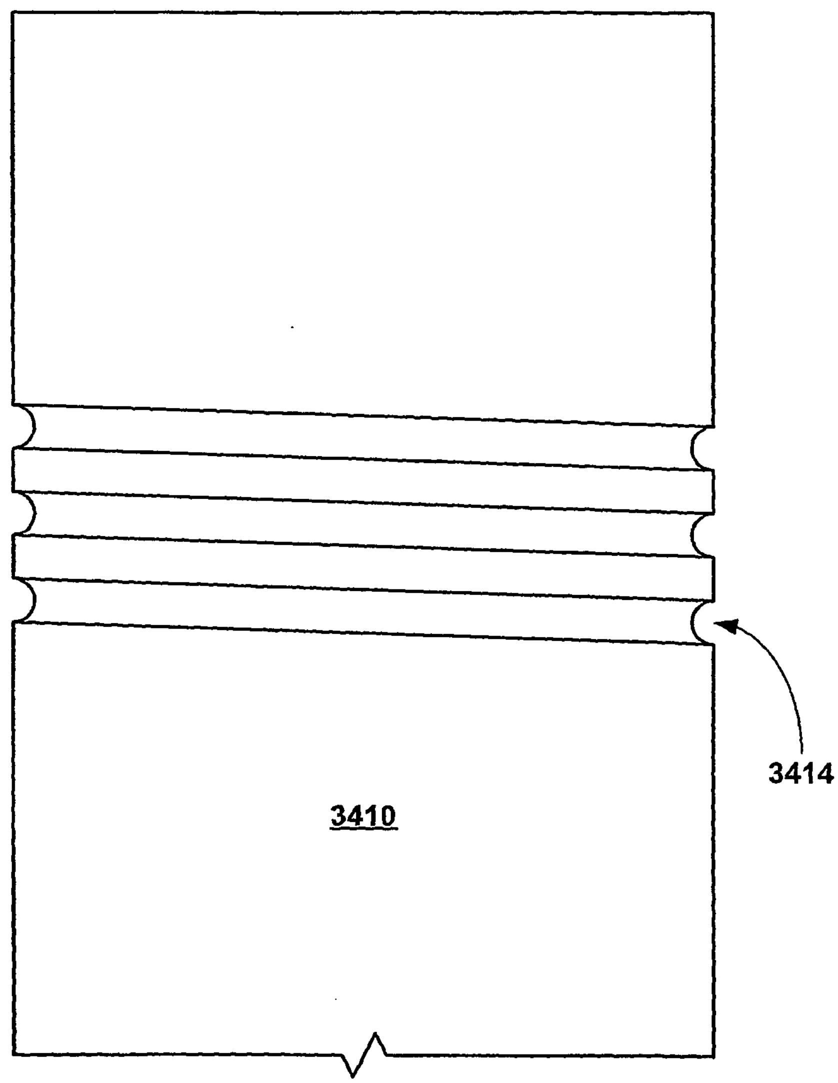


Fig. 34b

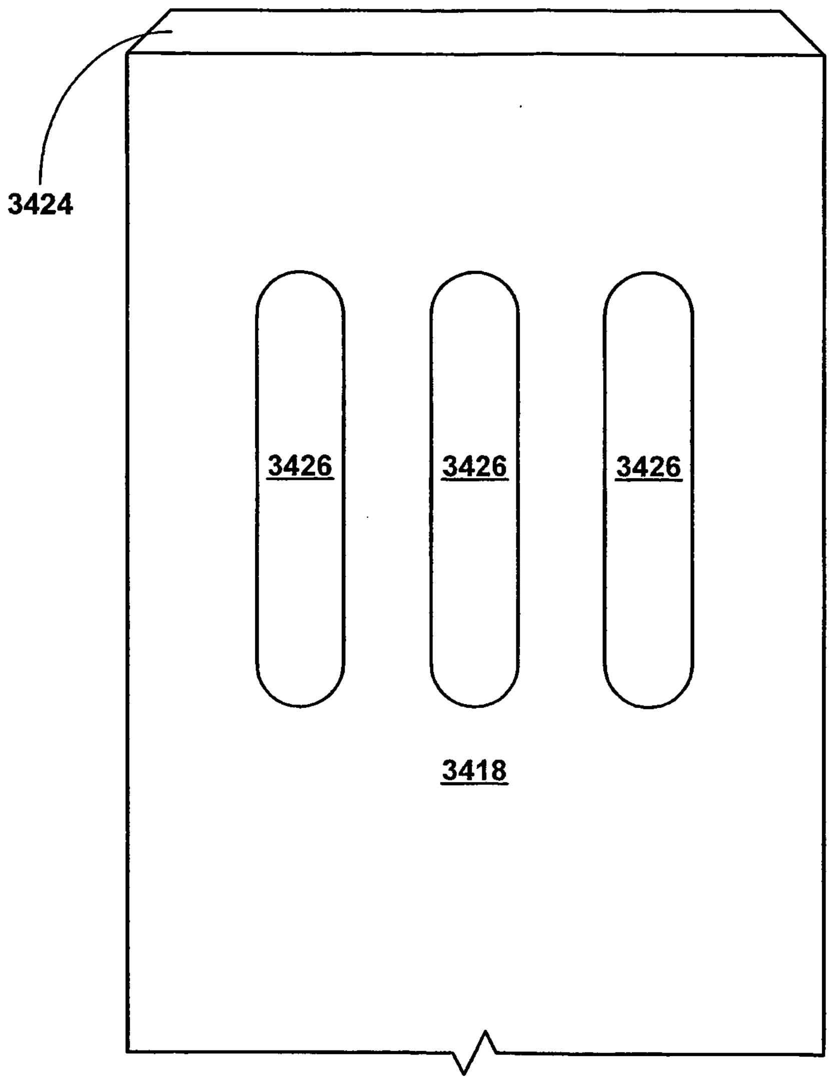


Fig. 34c

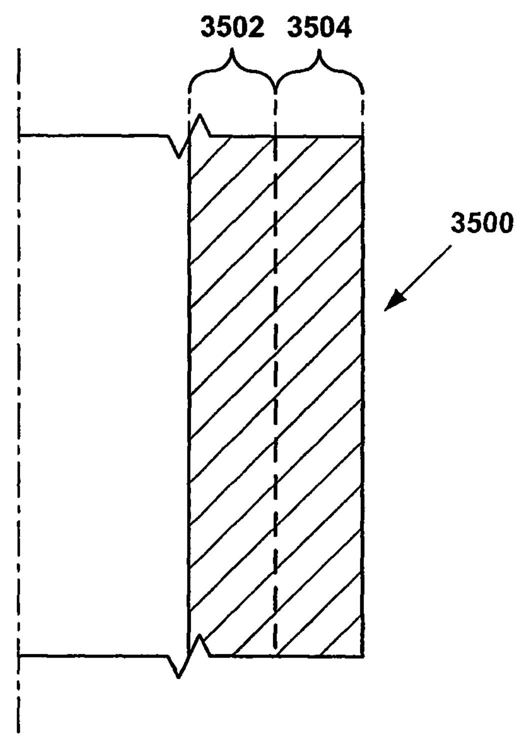


FIG. 35a

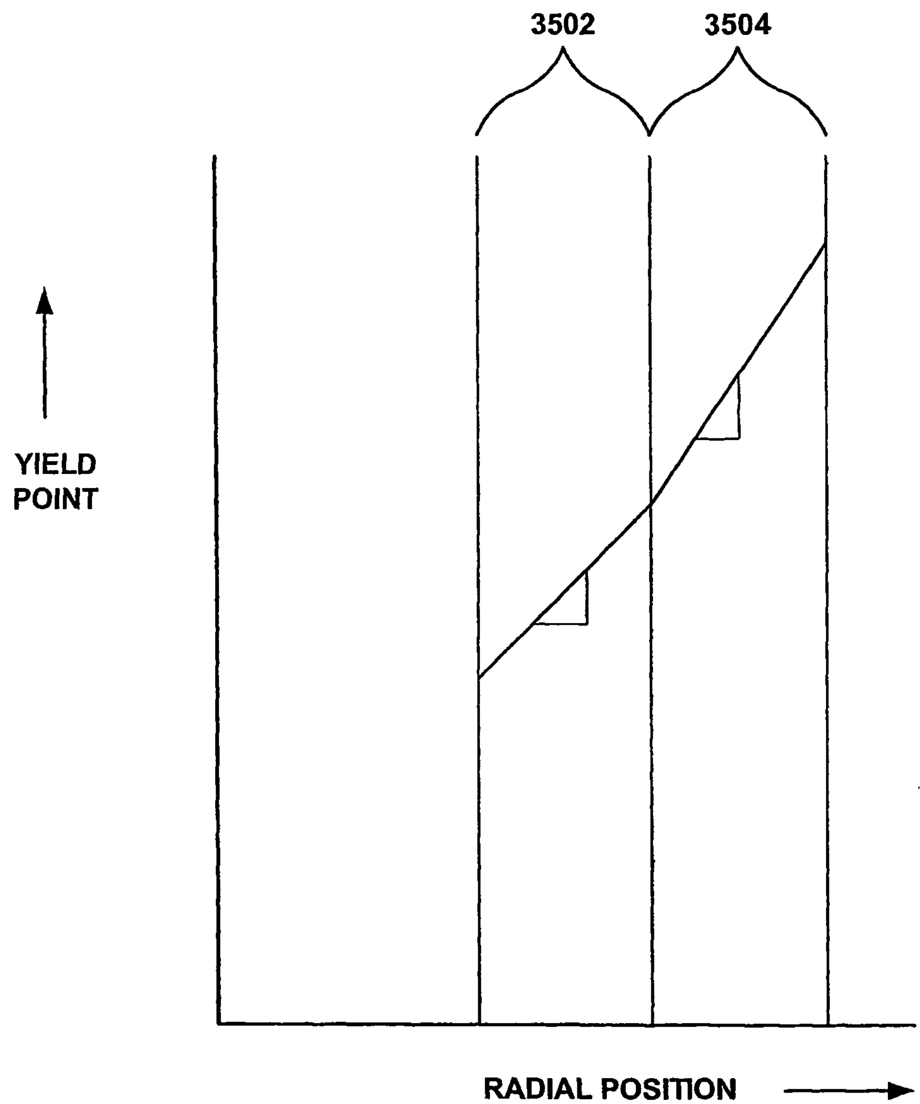


FIG. 35b

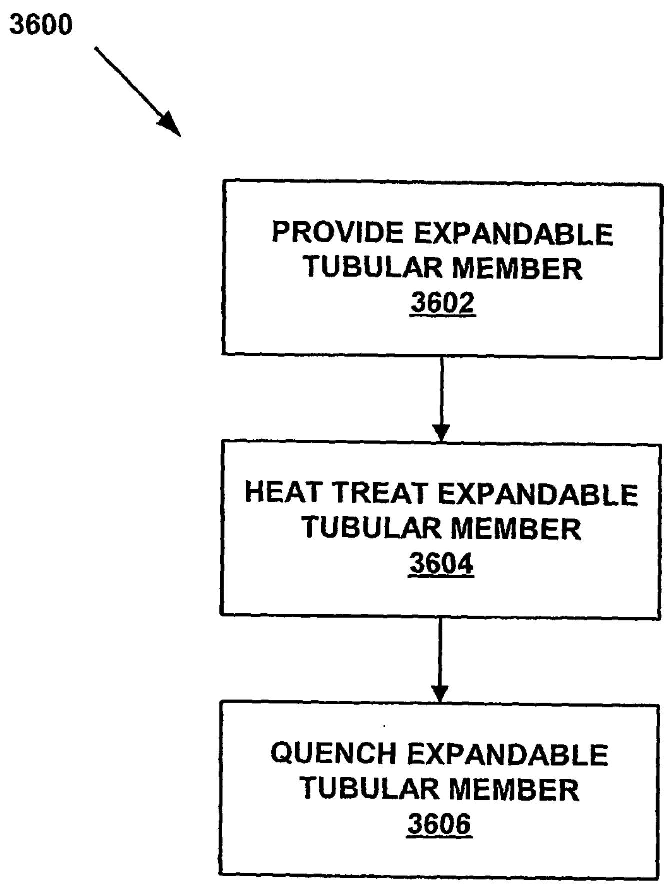
3600
PROVIDE EXPANDABLE TUBULAR MEMBER 3602
HEAT TREAT EXPANDABLE TUBULAR MEMBER 3604
QUENCH EXPANDABLE TUBULAR MEMBER 3606

FIG. 36a

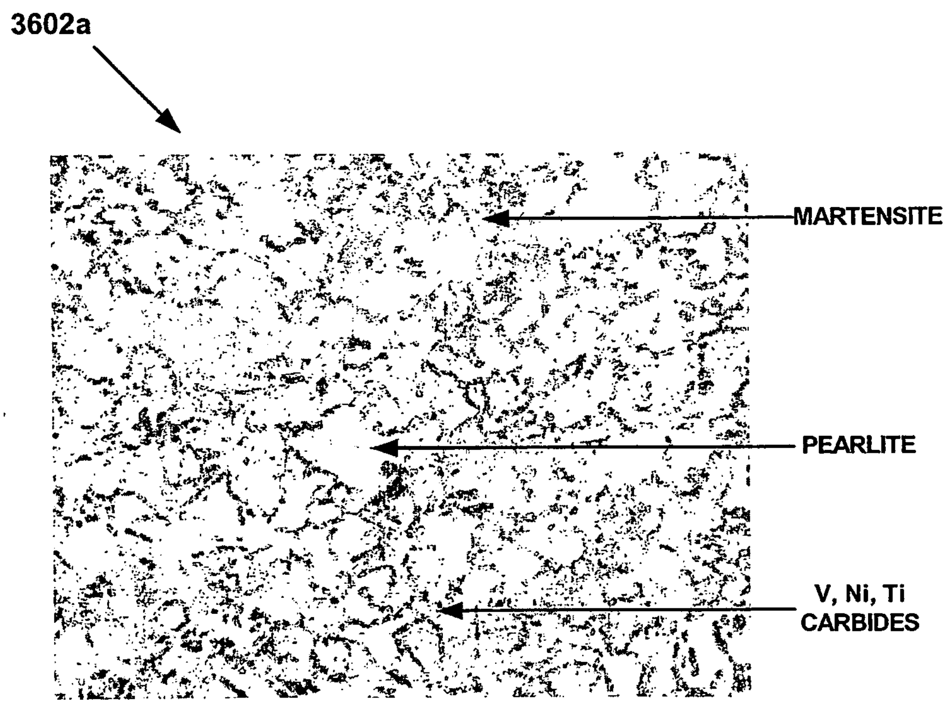


Fig. 36b

3602a

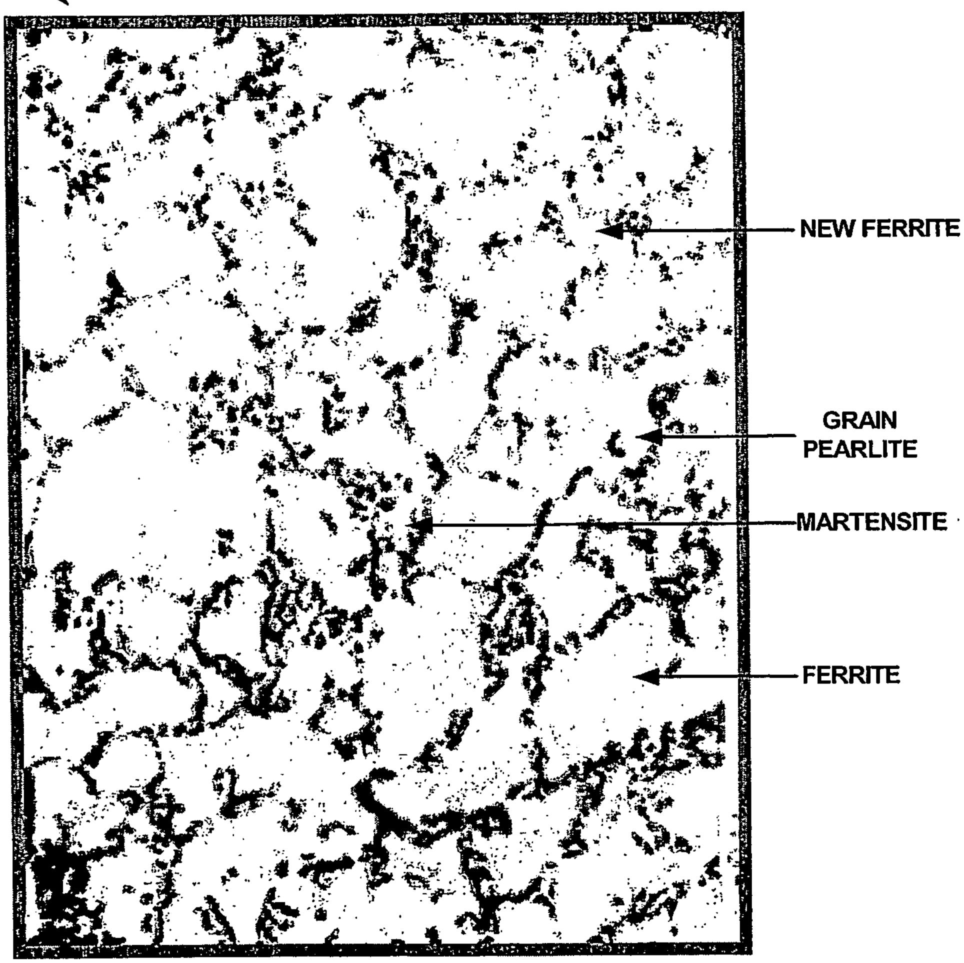


Fig. 36c

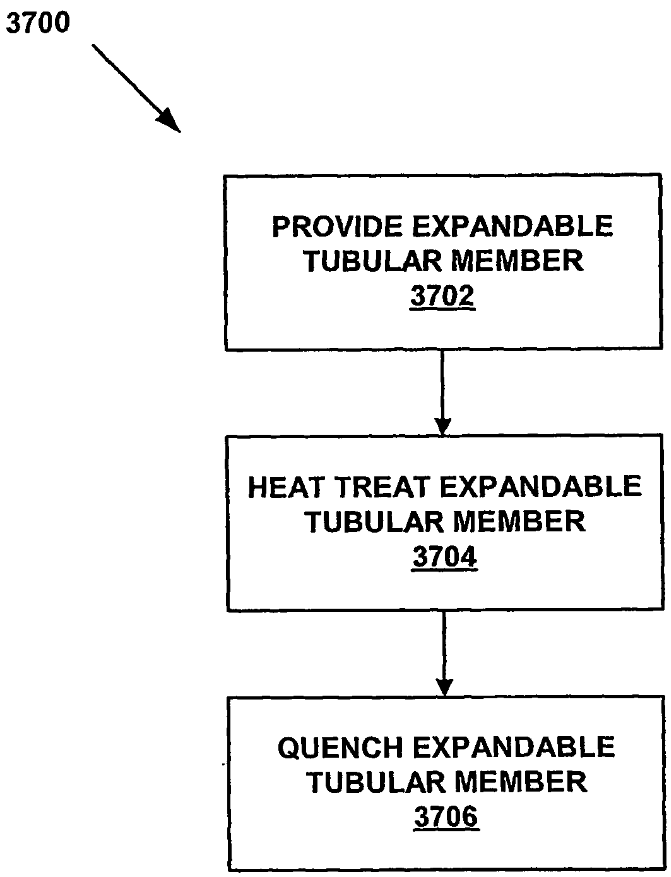
3700
PROVIDE EXPANDABLE TUBULAR MEMBER
3702
HEAT TREAT EXPANDABLE TUBULAR MEMBER
3704
QUENCH EXPANDABLE TUBULAR MEMBER
3706

FIG. 37a

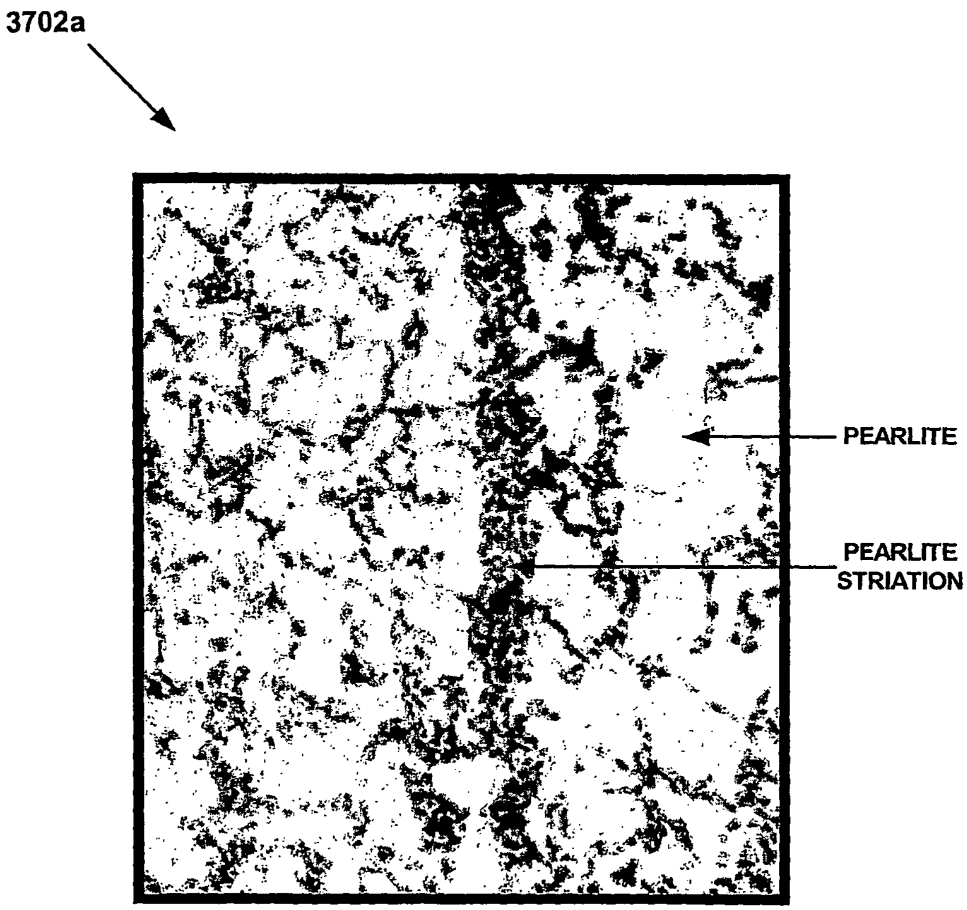


Fig. 37b

3702a


Fig. 37c

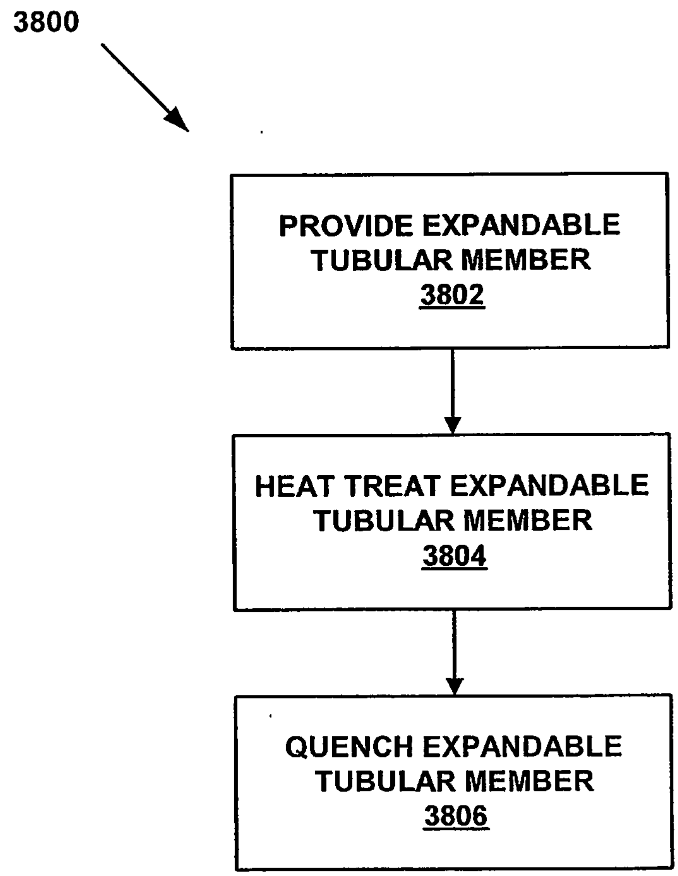
3800
PROVIDE EXPANDABLE TUBULAR MEMBER 3802
HEAT TREAT EXPANDABLE TUBULAR MEMBER 3804
QUENCH EXPANDABLE TUBULAR MEMBER 3806

FIG. 38a

3802a


Fig. 38b

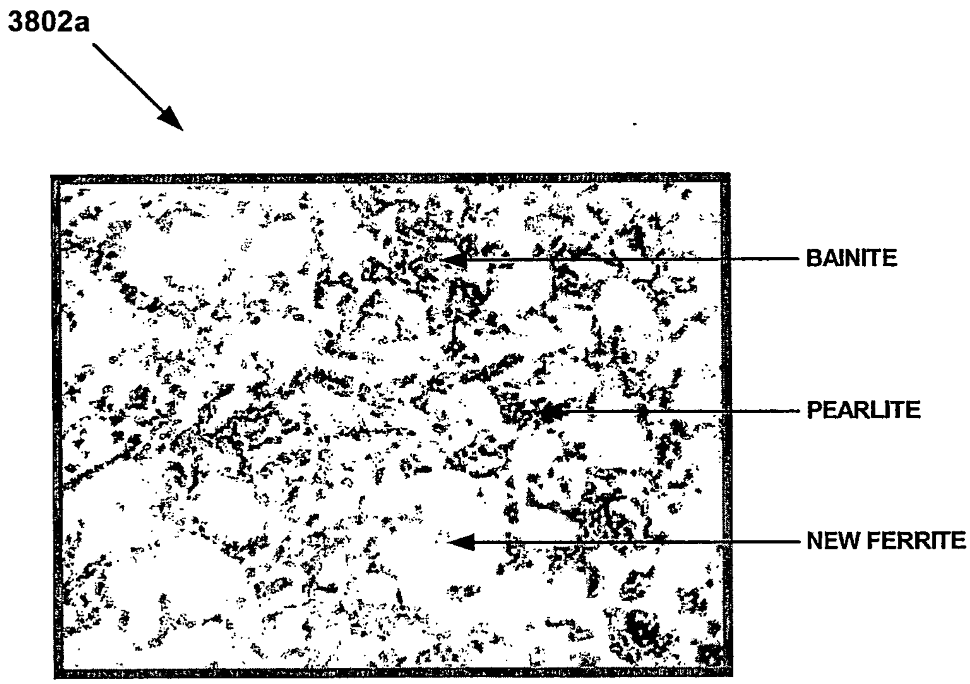


Fig. 38c

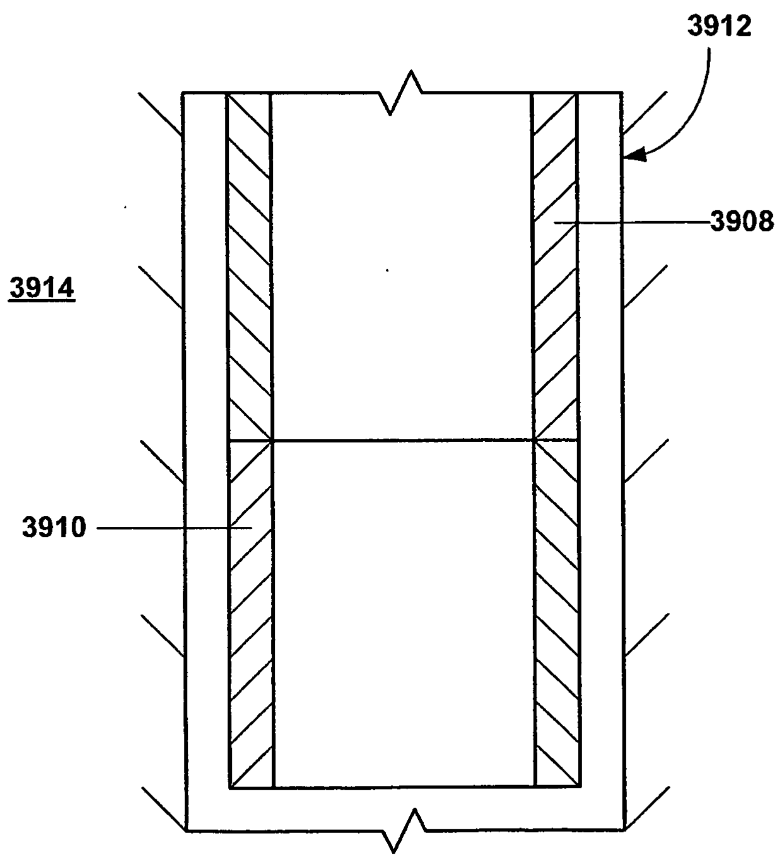


FIG. 39a

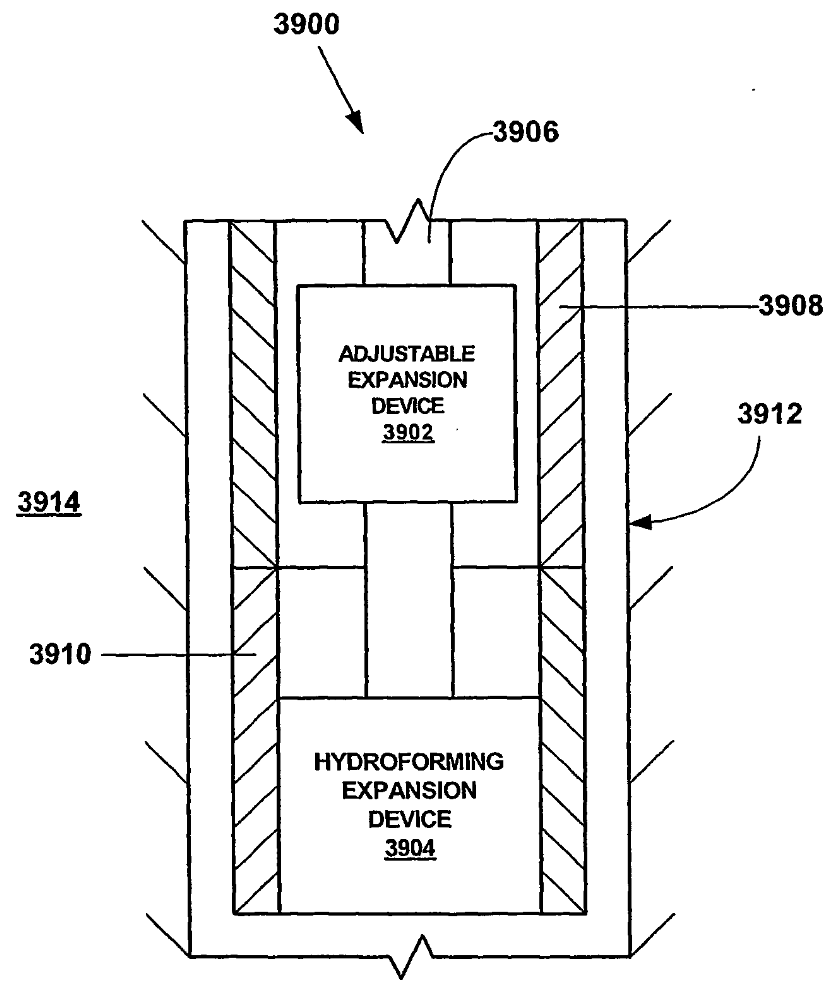
3900
3906
3908
ADJUSTABLE
EXPANSION
DEVICE
3902
3912
3914
3910
HYDROFORMING
EXPANSION
DEVICE
3904

FIG. 39b

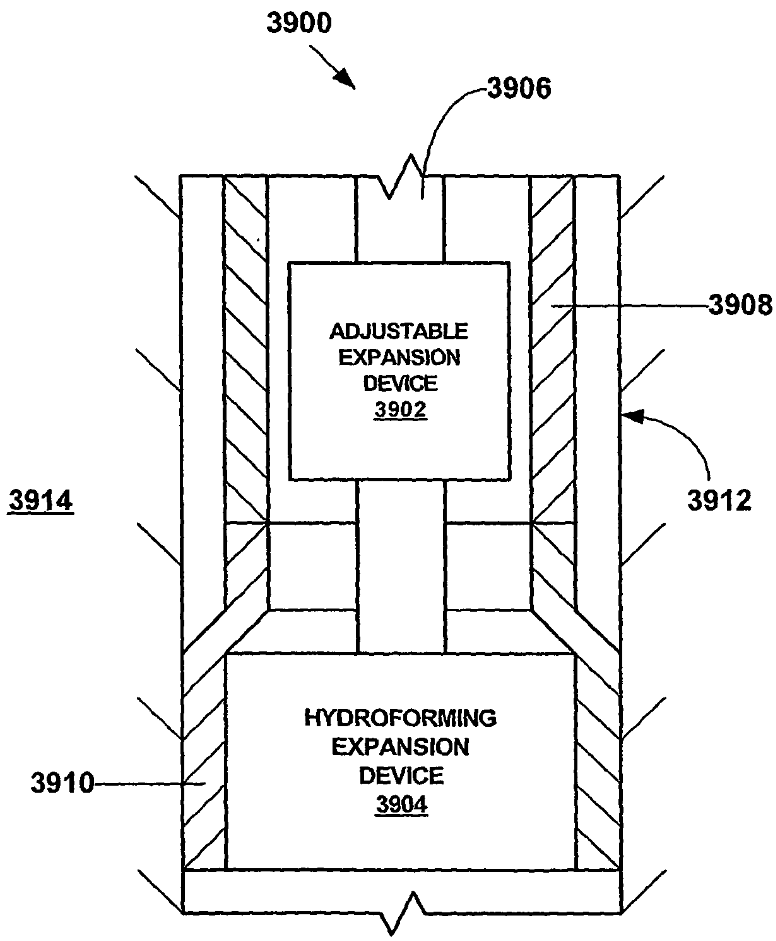
3900
3906
3908
ADJUSTABLE
EXPANSION
DEVICE
3902
3914
3912
HYDROFORMING
EXPANSION
DEVICE
3904
3910

FIG. 39c

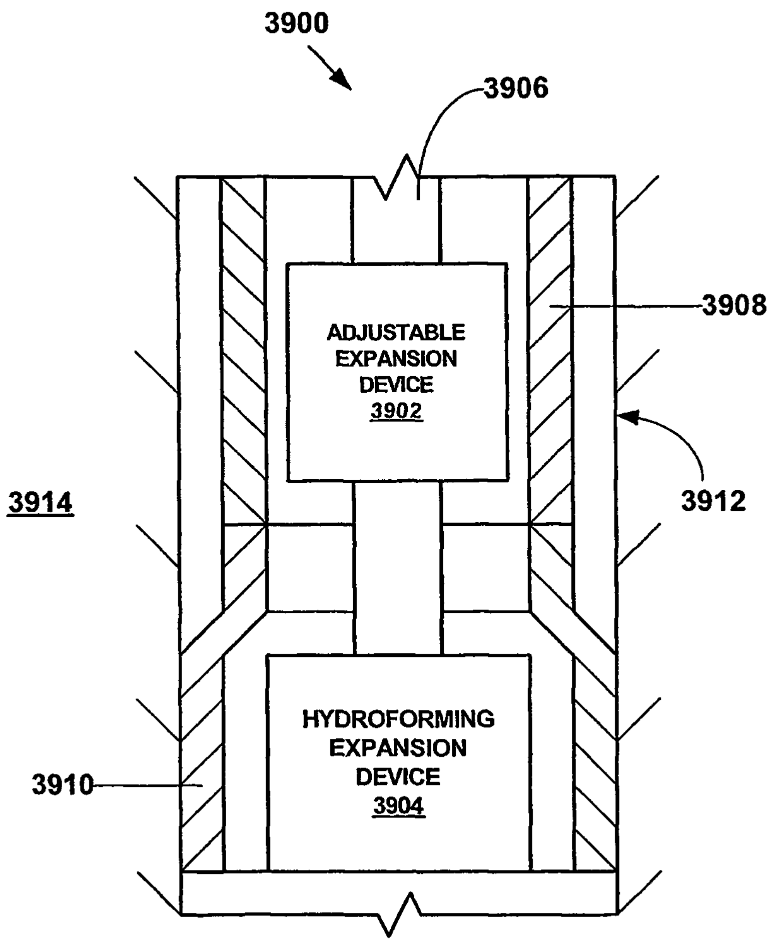
3900
3906
3908
ADJUSTABLE
EXPANSION
DEVICE
3902
3914
3912
HYDROFORMING
EXPANSION
DEVICE
3904
3910

FIG. 39d

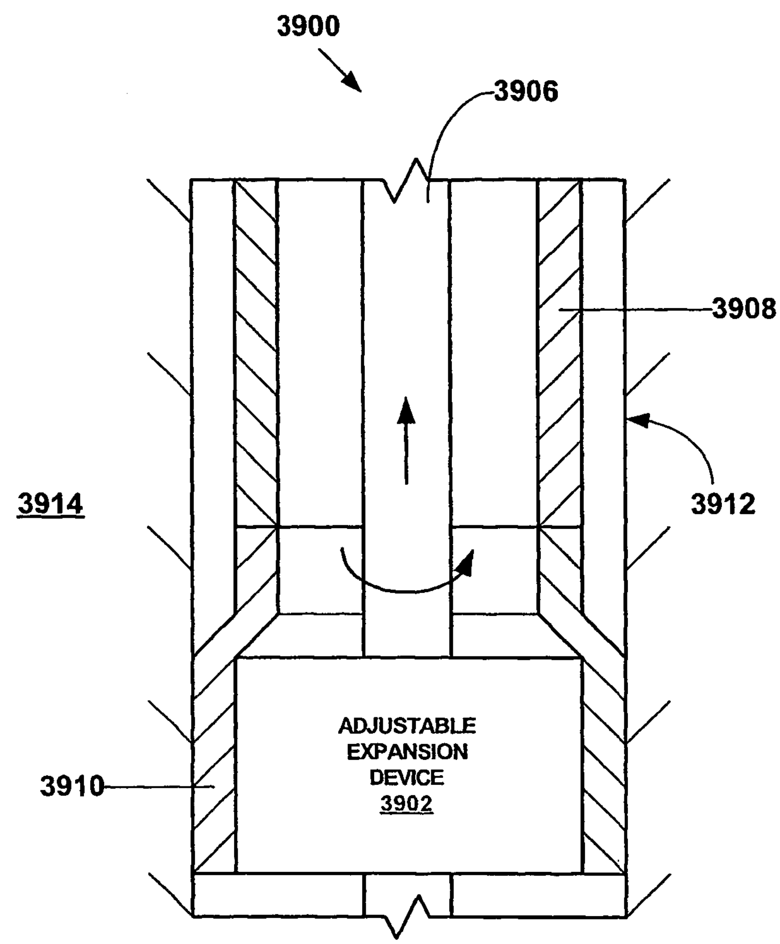
3900
3906
3908
3914
3912
ADJUSTABLE
EXPANSION
DEVICE
3902
3910

FIG. 39e

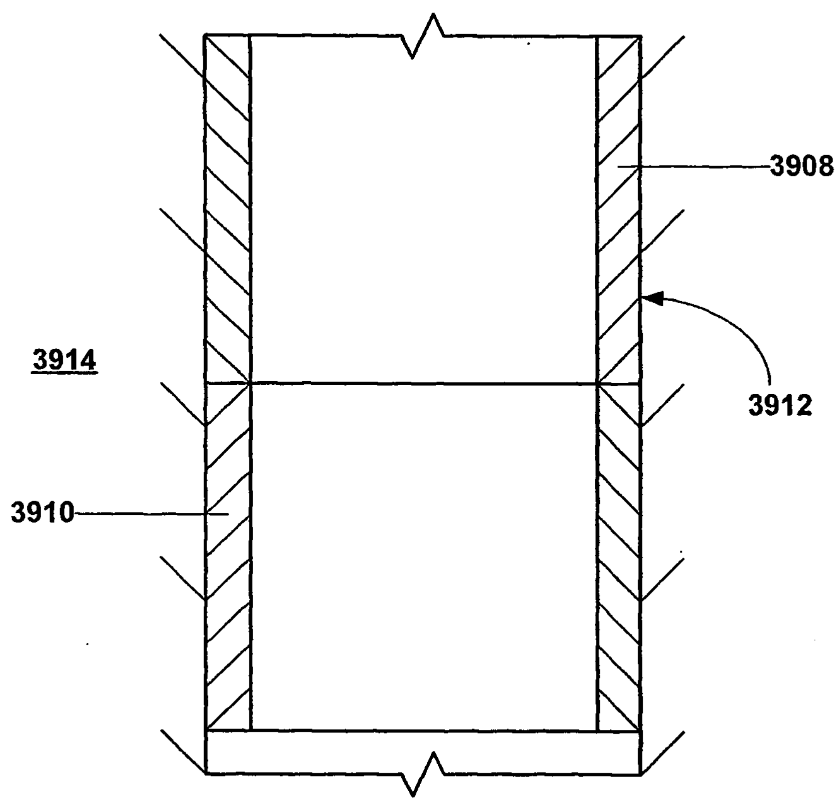


FIG. 39f

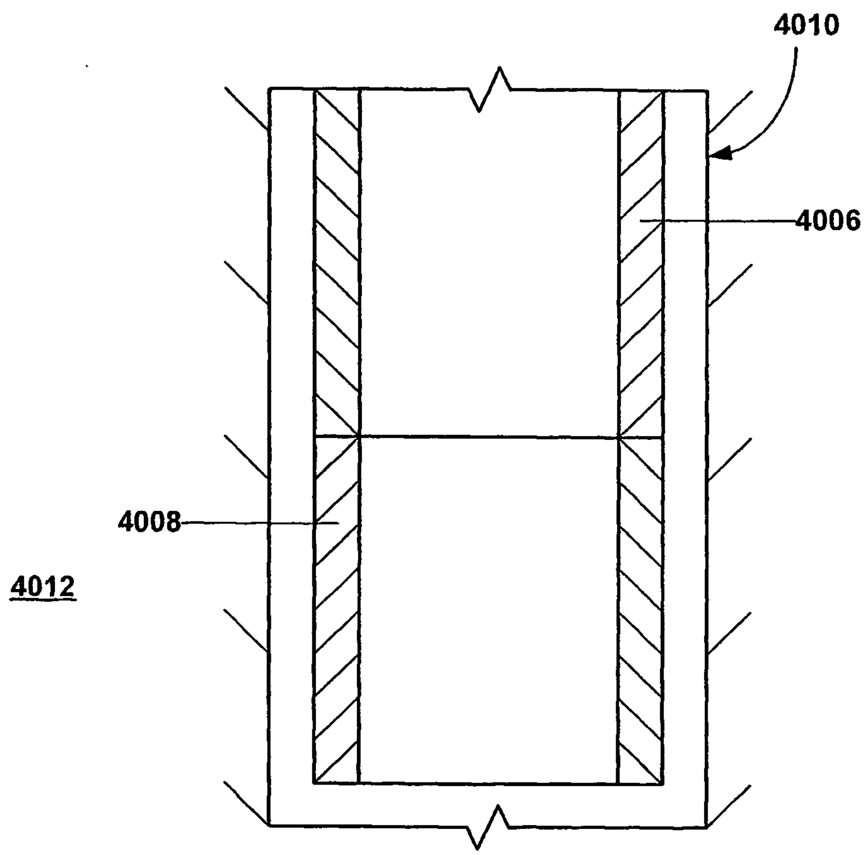


FIG. 40a

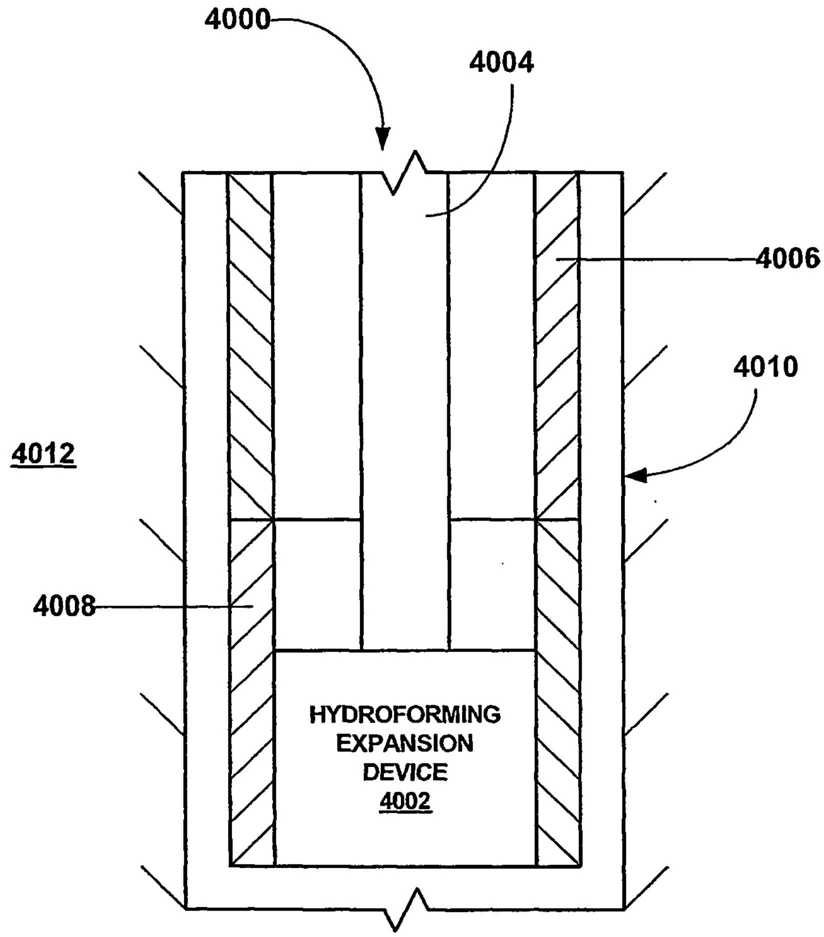
4000
4004
4006
4010
4012
4008
HYDROFORMING
EXPANSION
DEVICE
4002

FIG. 40b

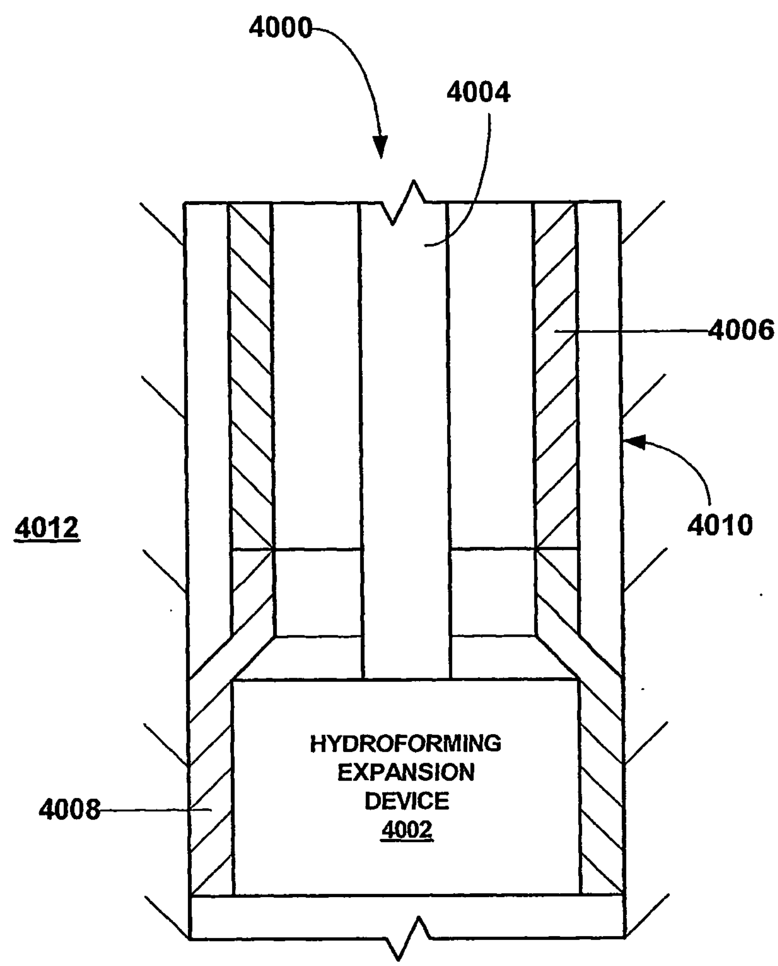
4000
4004
4006
4010
4012
HYDROFORMING
EXPANSION
DEVICE
4002
4008

FIG. 40c

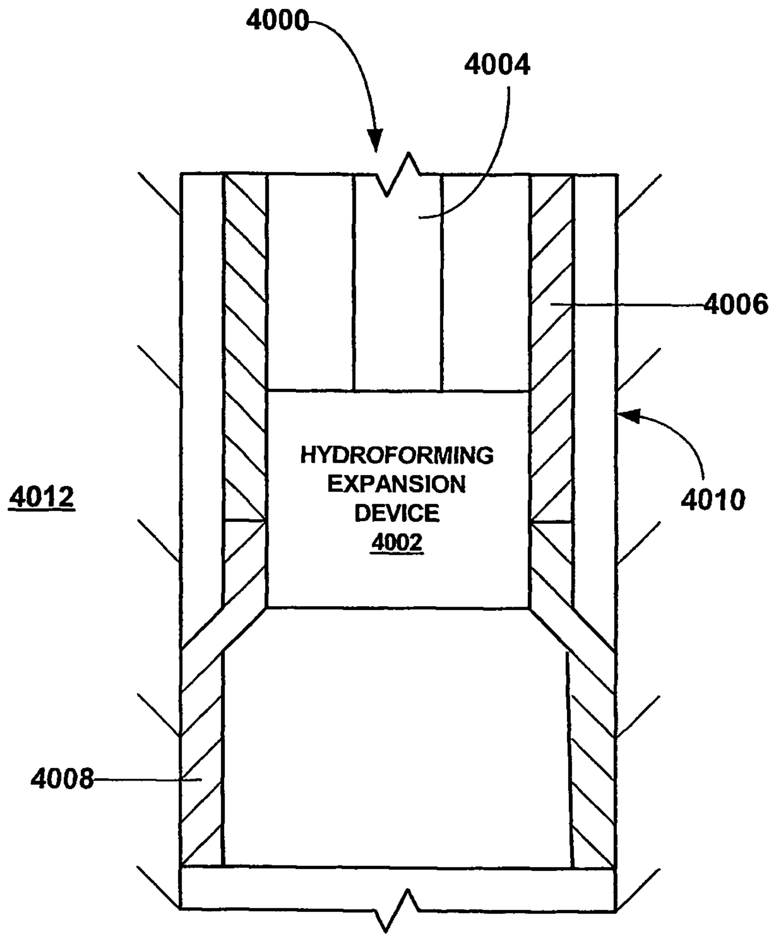
4000
4004
4006
HYDROFORMING
EXPANSION
DEVICE
4002
4012
4010
4008

FIG. 40d

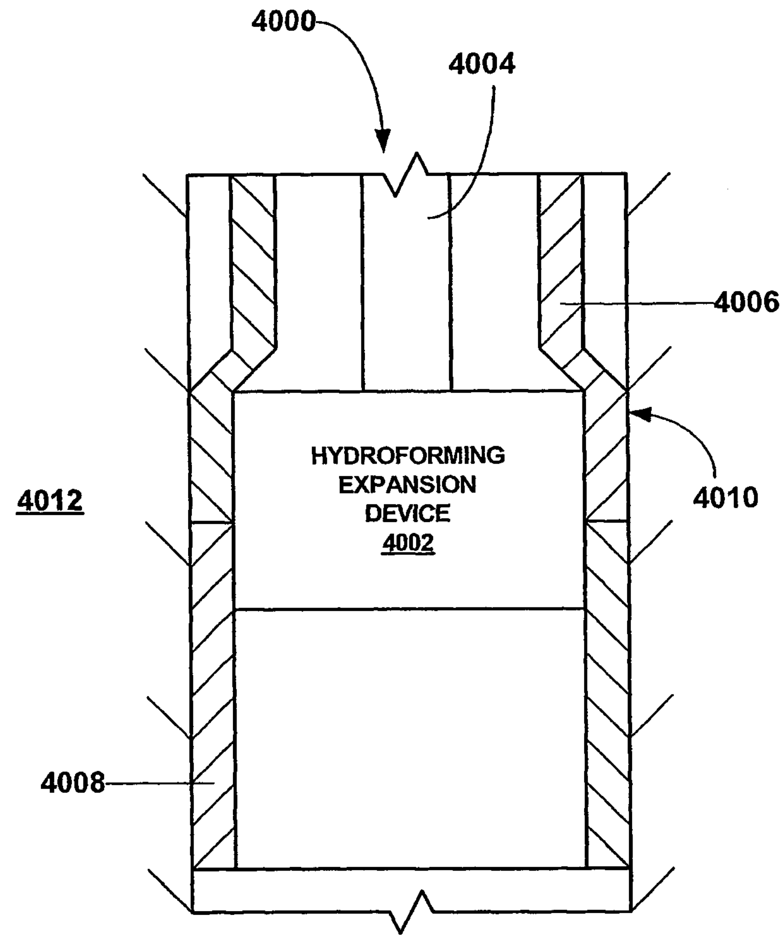
4000
4004
4006
HYDROFORMING
EXPANSION
DEVICE
4002
4010
4012
4008

FIG. 40e

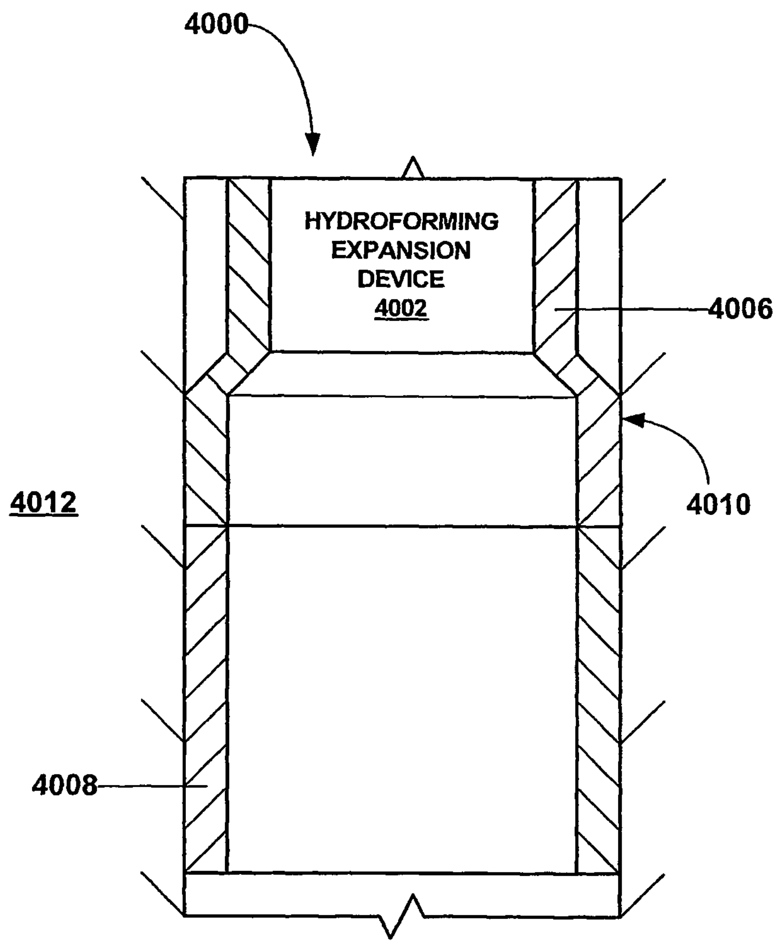
4000
HYDROFORMING
EXPANSION
DEVICE
4002
4006
4010
4012
4008

FIG. 40f

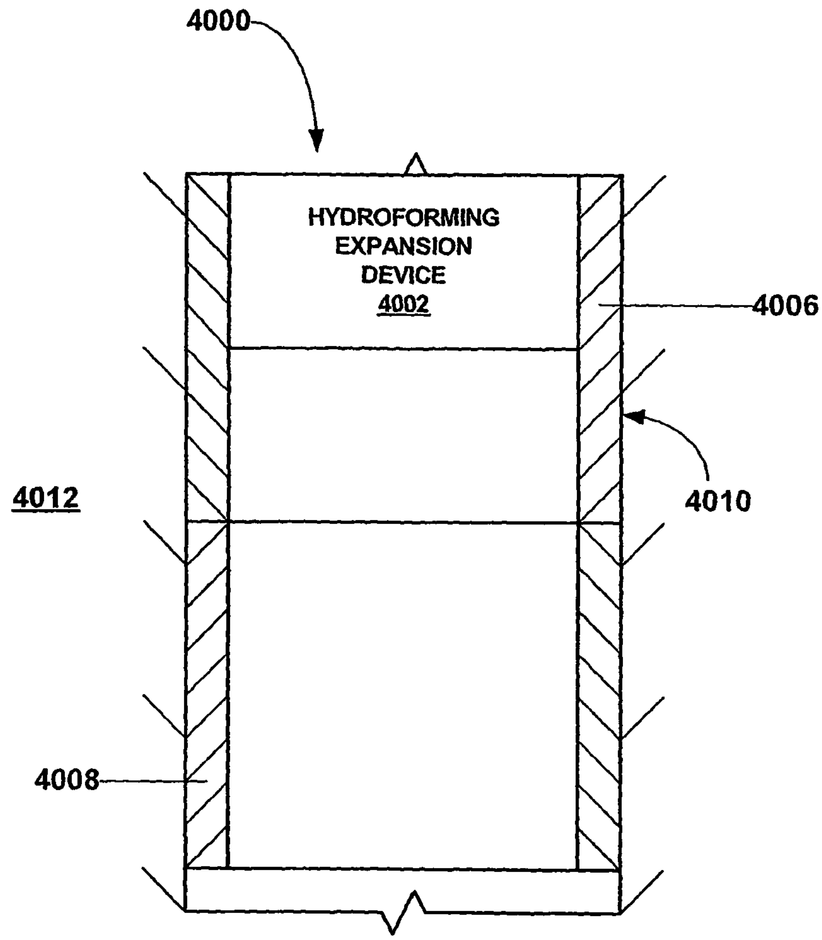
4000
HYDROFORMING
EXPANSION
DEVICE
4002
4006
4012
4010
4008

FIG. 40g

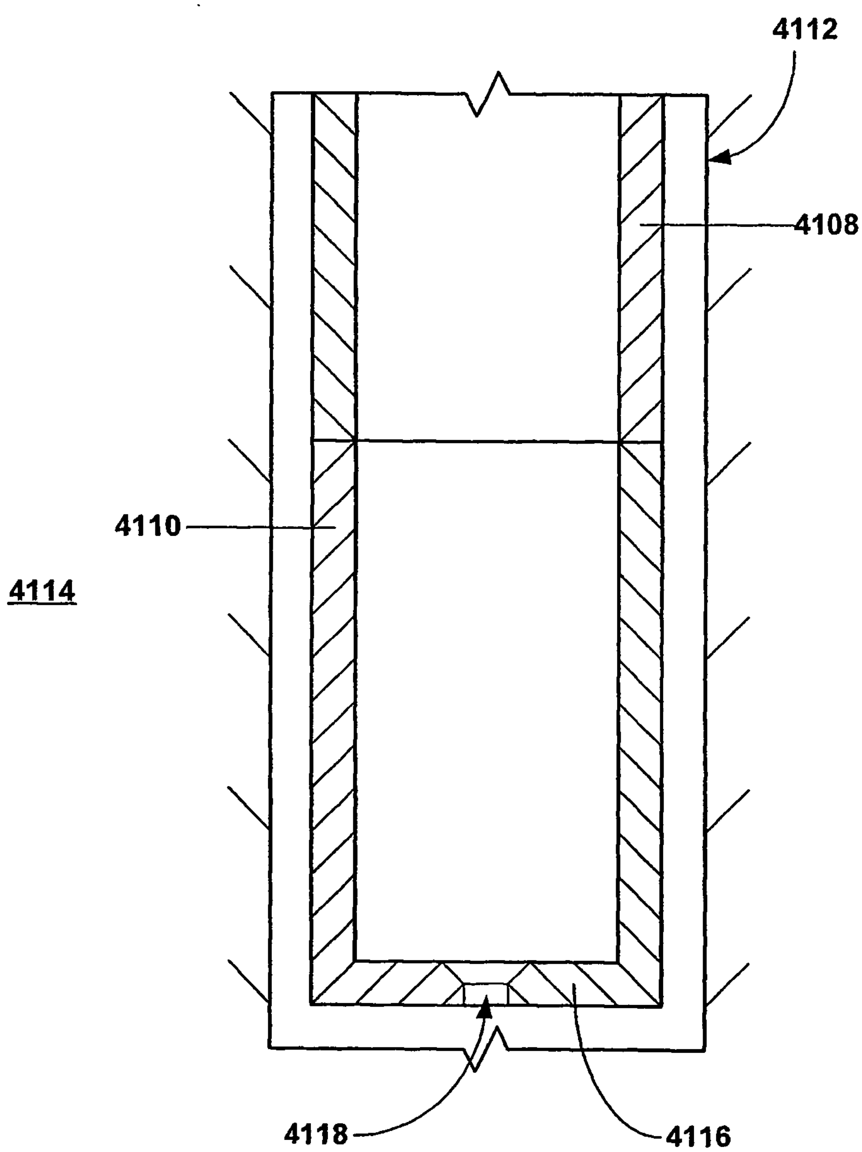


FIG. 41a

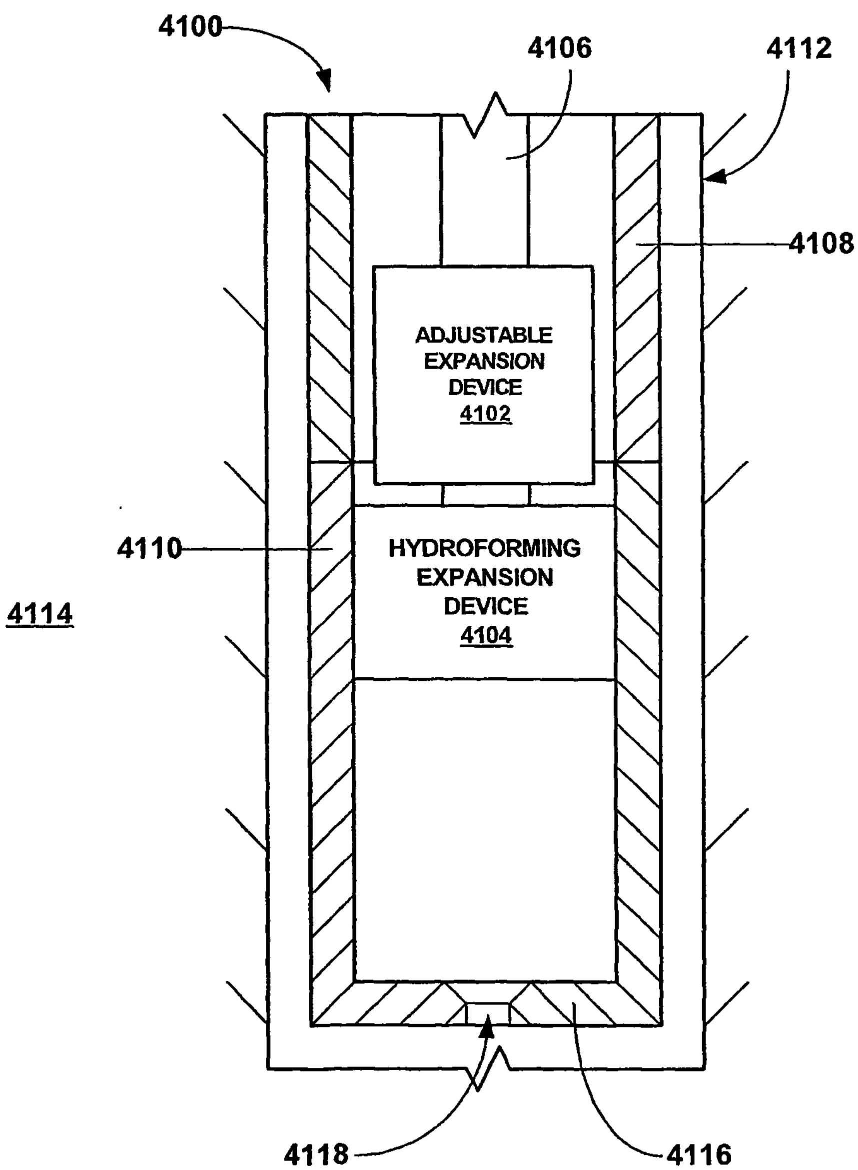
4100
4106
4112
4108
ADJUSTABLE
EXPANSION
DEVICE
4102
4110
HYDROFORMING
EXPANSION
DEVICE
4104
4114
4118
4116

FIG. 41b

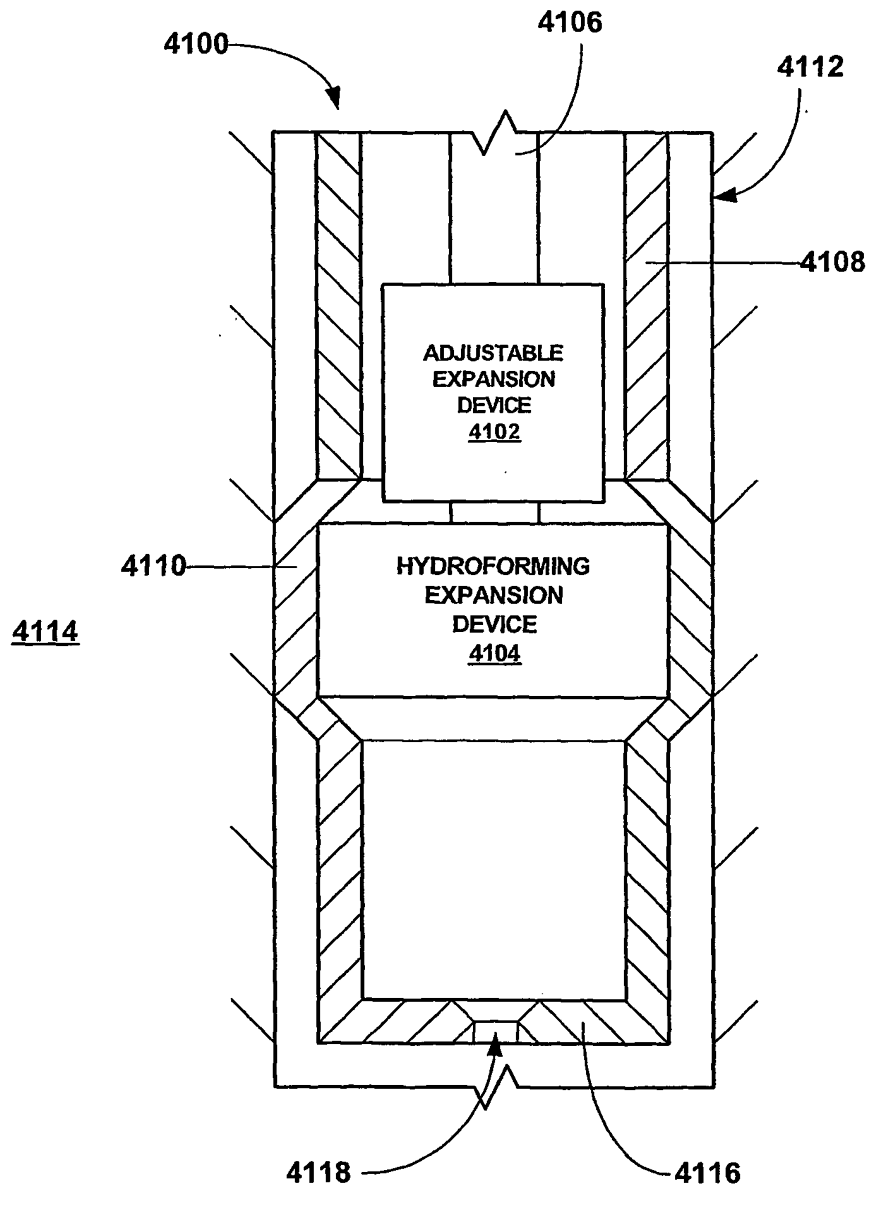
4100
4106
4112
4108
ADJUSTABLE
EXPANSION
DEVICE
4102
4110
HYDROFORMING
EXPANSION
DEVICE
4104
4114
4118
4116

FIG. 41c

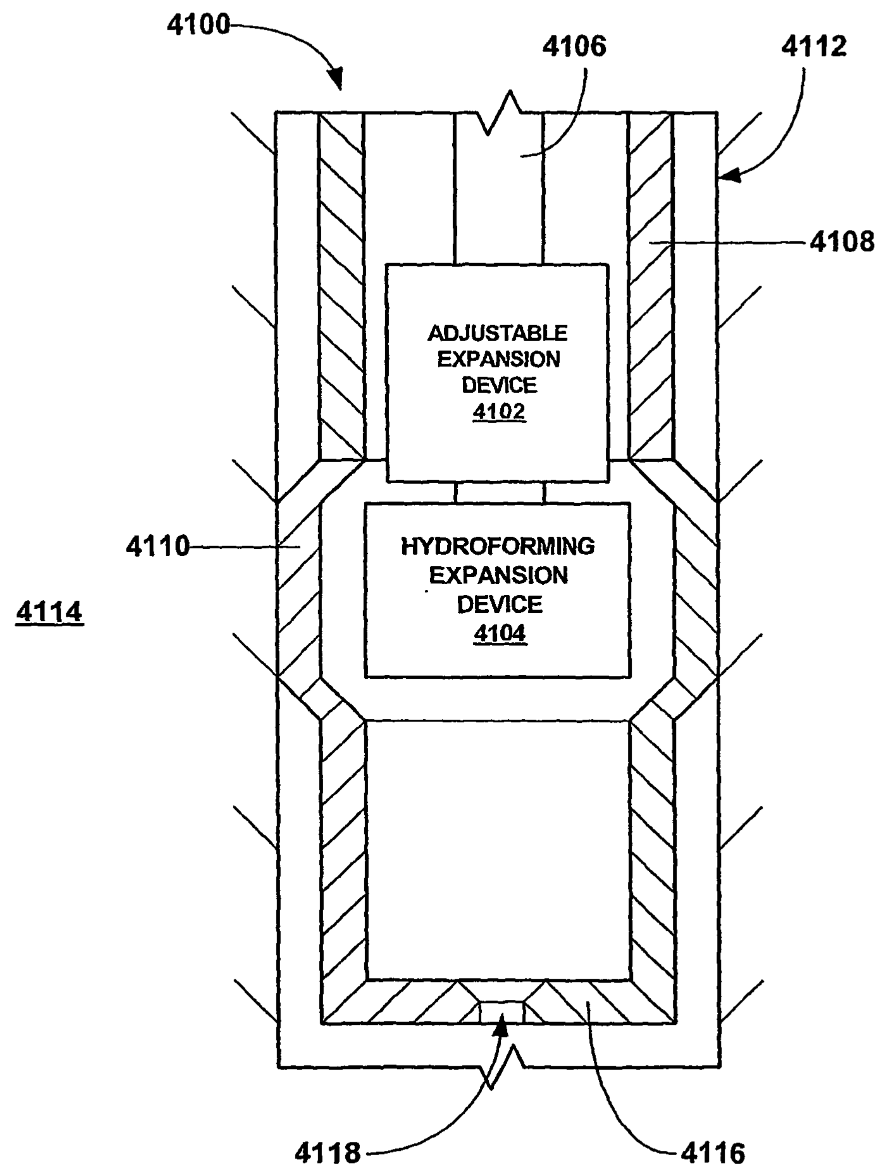
4100
4106
4112
4108
ADJUSTABLE
EXPANSION
DEVICE
4102
4110
HYDROFORMING
EXPANSION
DEVICE
4104
4114
4118
4116

FIG. 41d

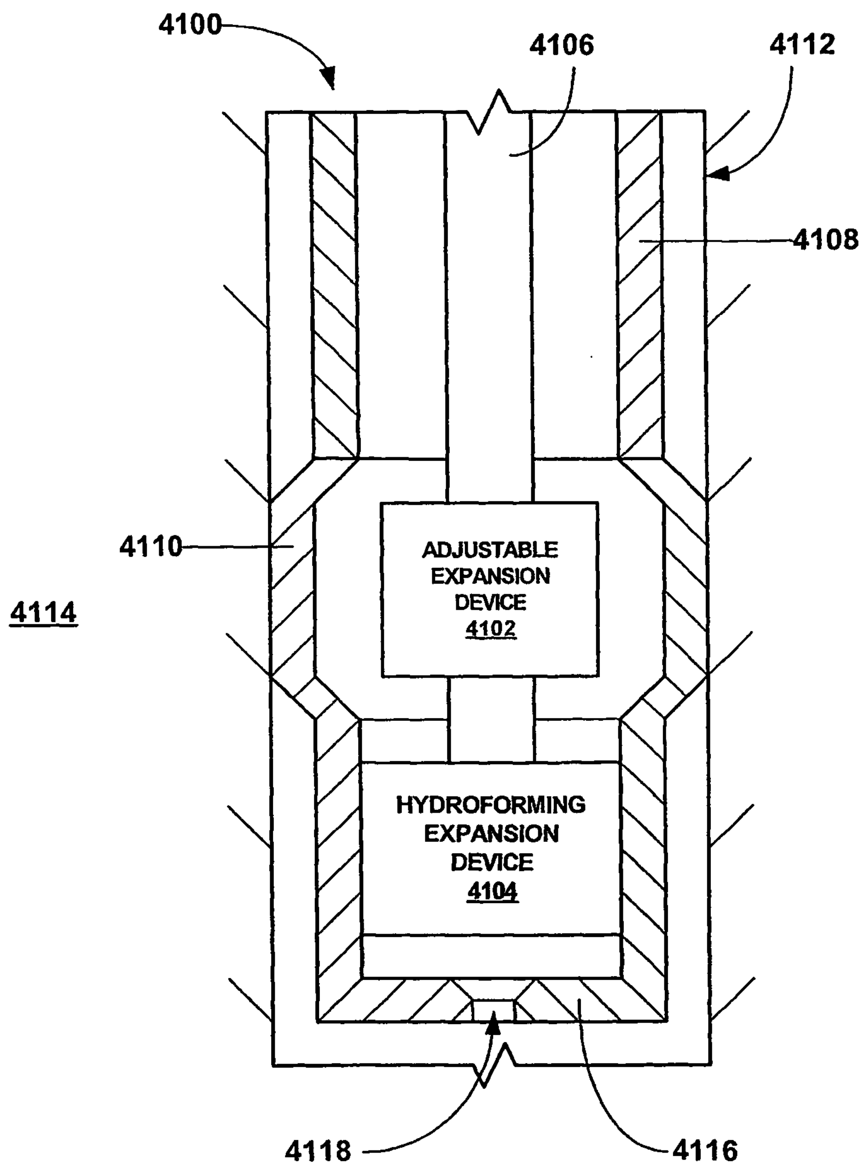
4100
4106
4112
4108
4110
4114
ADJUSTABLE
EXPANSION
DEVICE
4102
HYDROFORMING
EXPANSION
DEVICE
4104
4118
4116

FIG. 41e

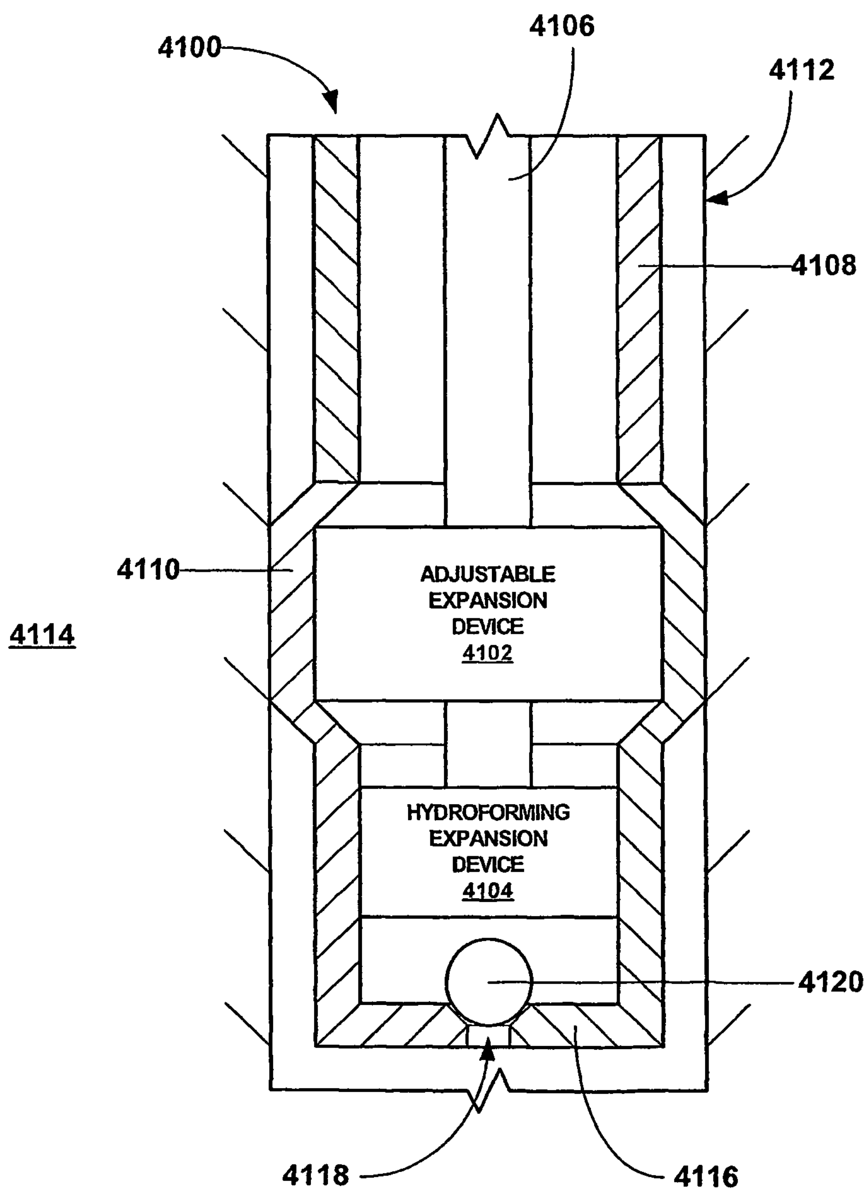
4100
4106
4112
4108
4110
ADJUSTABLE EXPANSION DEVICE 4102
4114
HYDROFORMING EXPANSION DEVICE 4104
4120
4118
4116

FIG. 41f

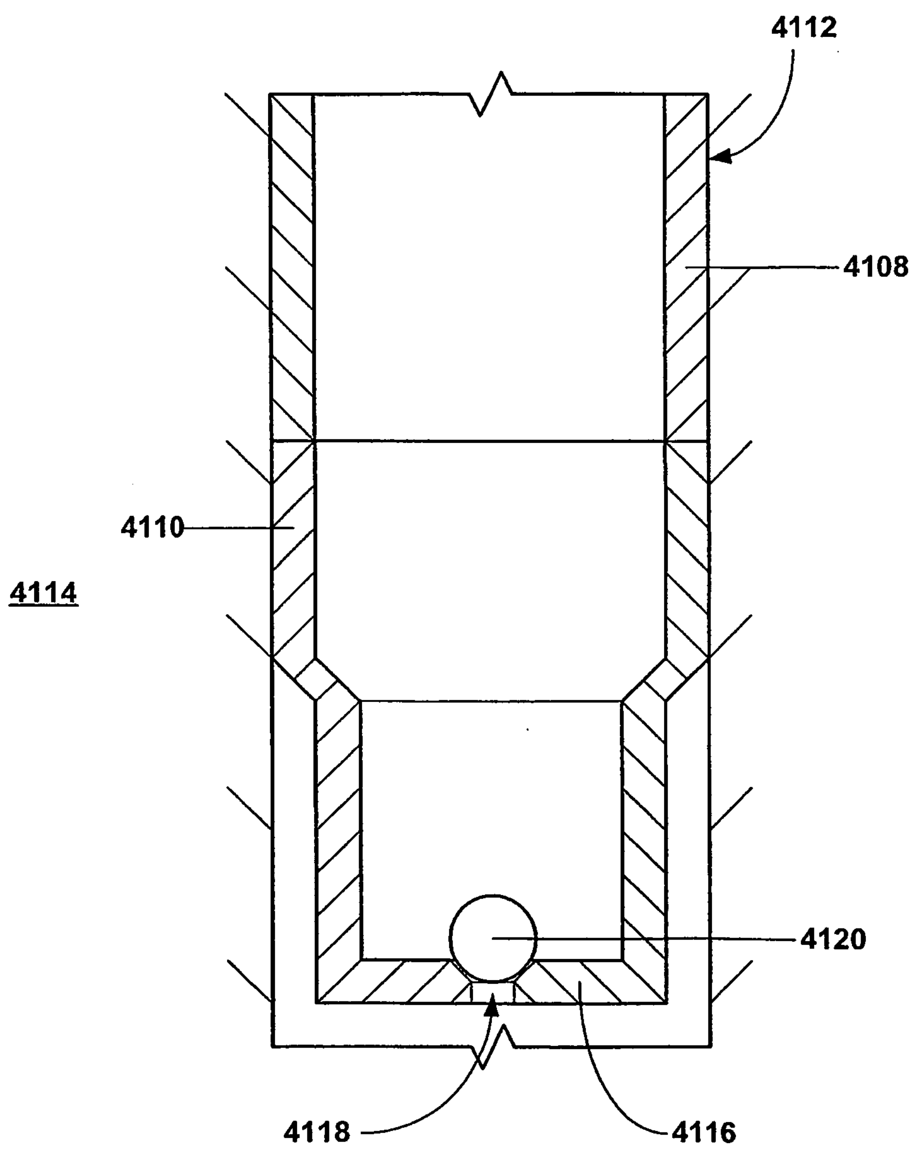


FIG. 41g

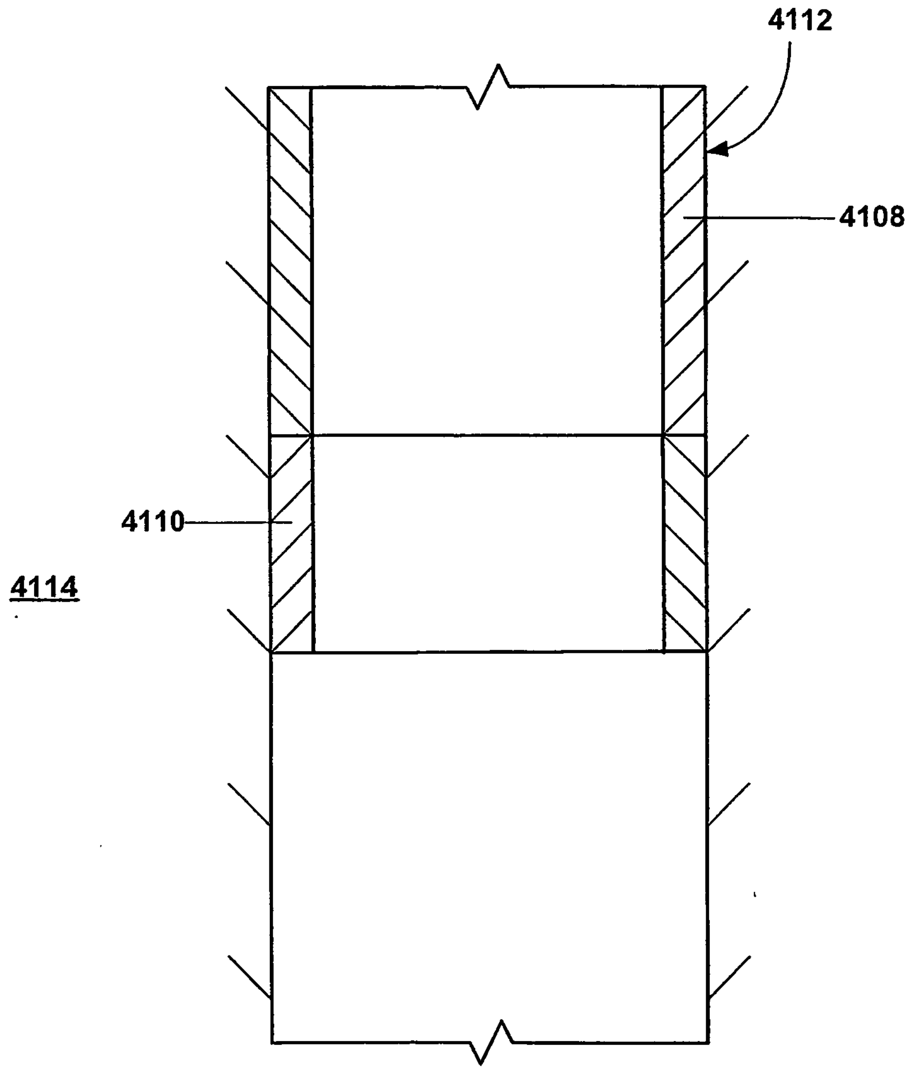


FIG. 41h

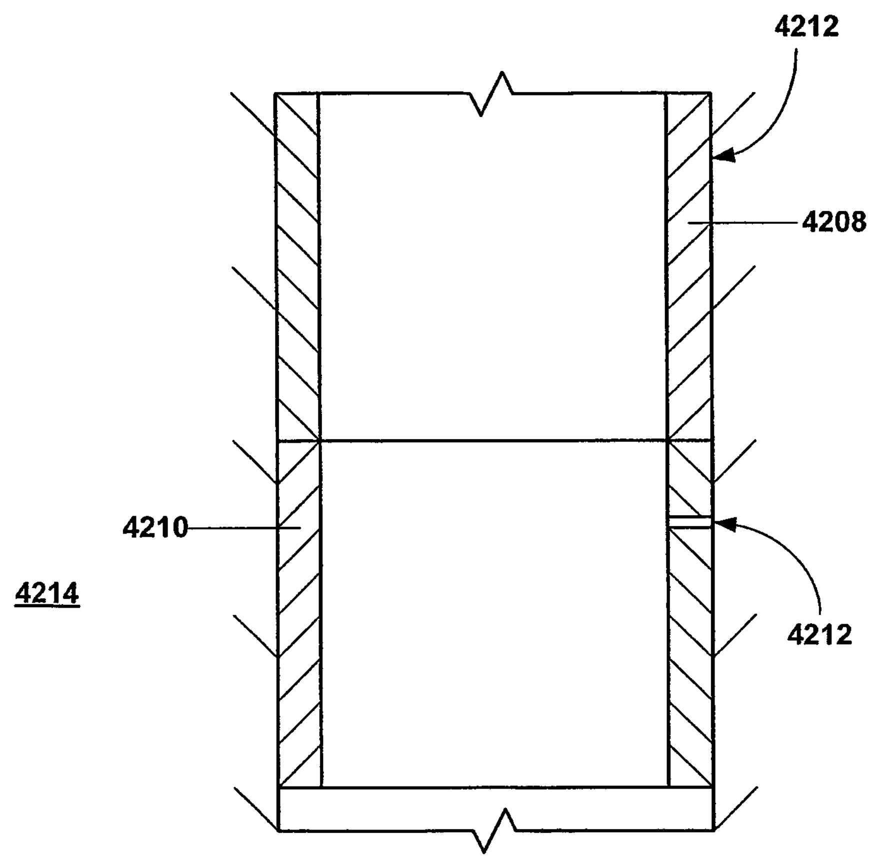


FIG. 42a

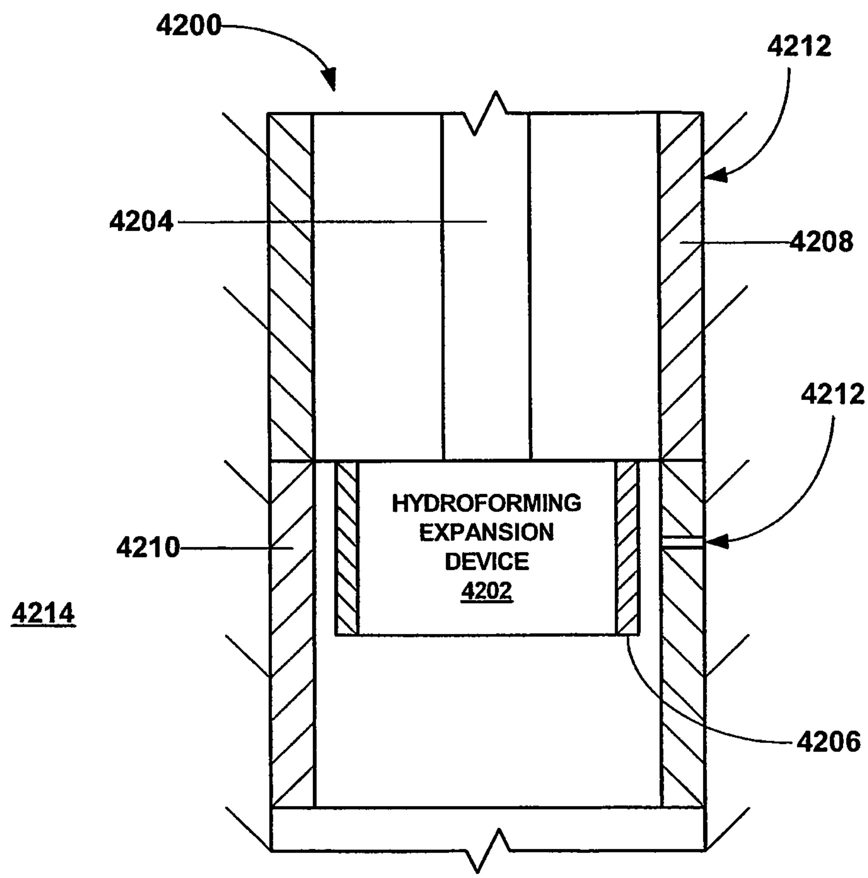
4200
4212
4204
4208
4212
HYDROFORMING EXPANSION DEVICE 4202
4210
4214
4206

FIG. 42b

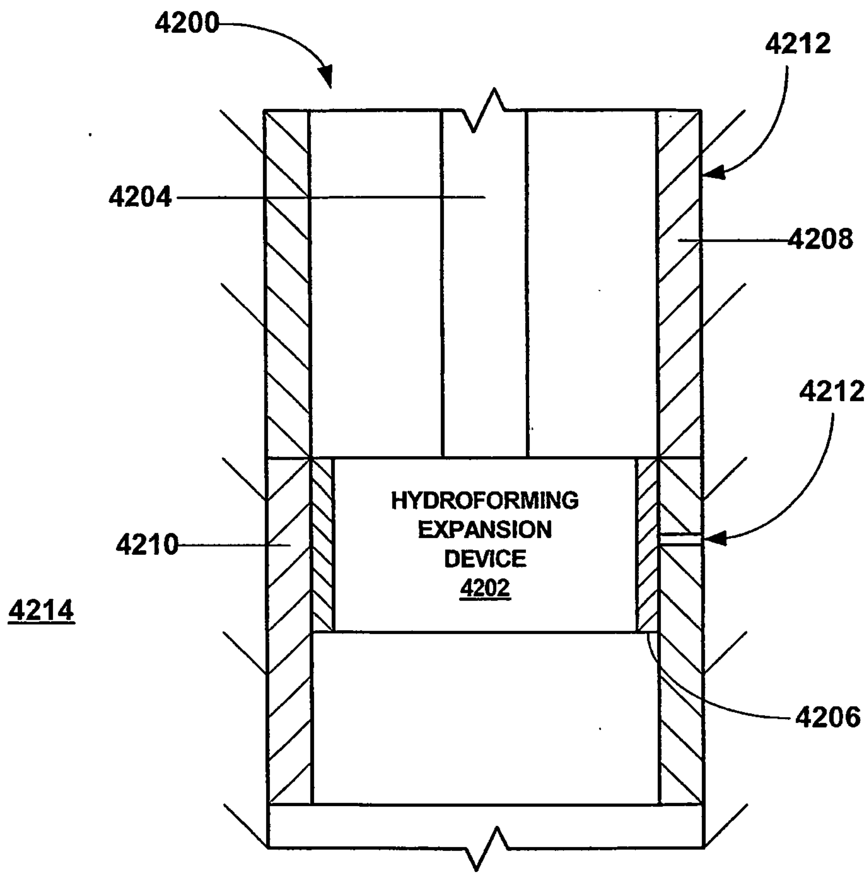
4200
4212
4204
4208
4212
HYDROFORMING
EXPANSION
DEVICE
4202
4210
4214
4206

FIG. 42c

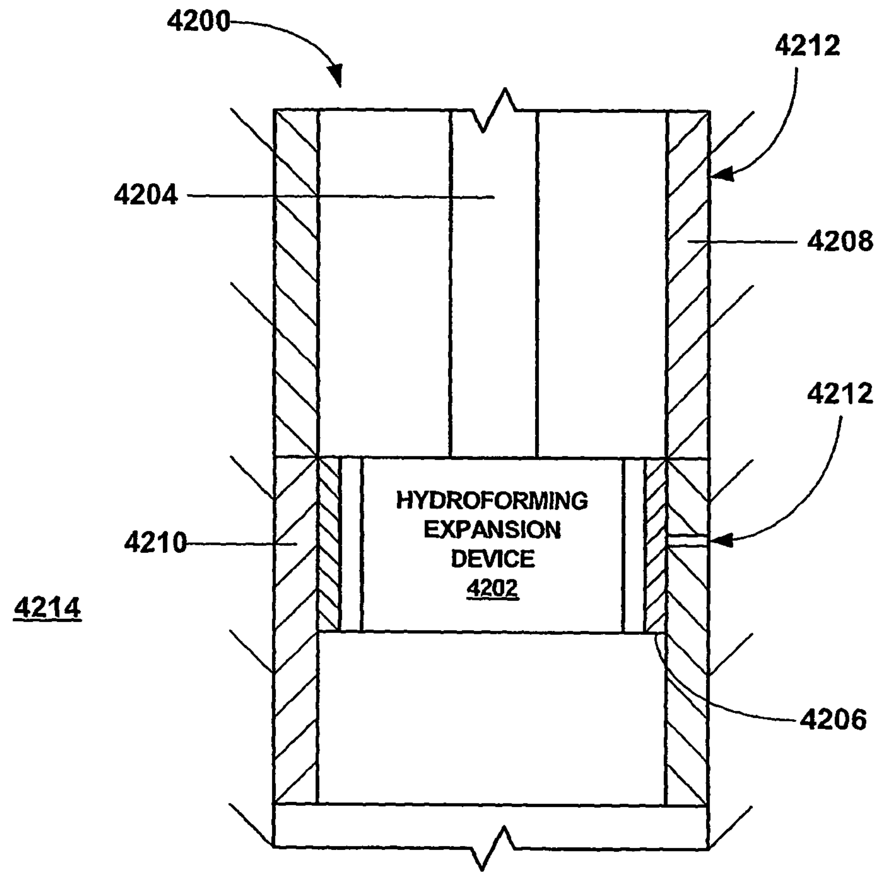
4200
4212
4204
4208
4212
HYDROFORMING EXPANSION DEVICE 4202
4210
4214
4206

FIG. 42d

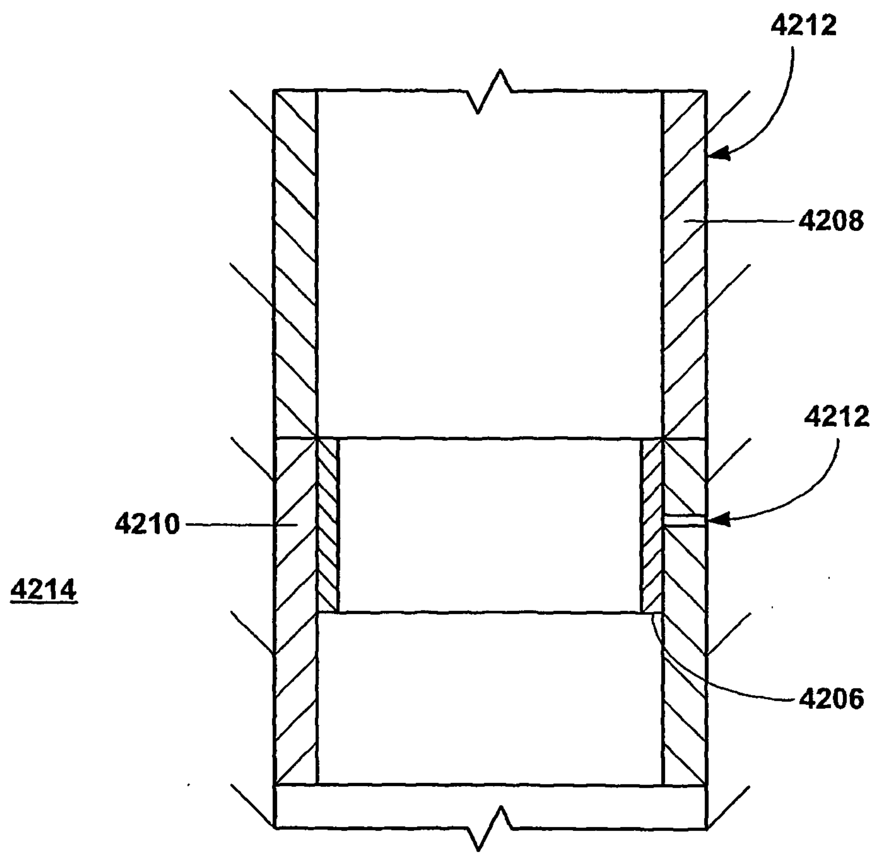


FIG. 42e

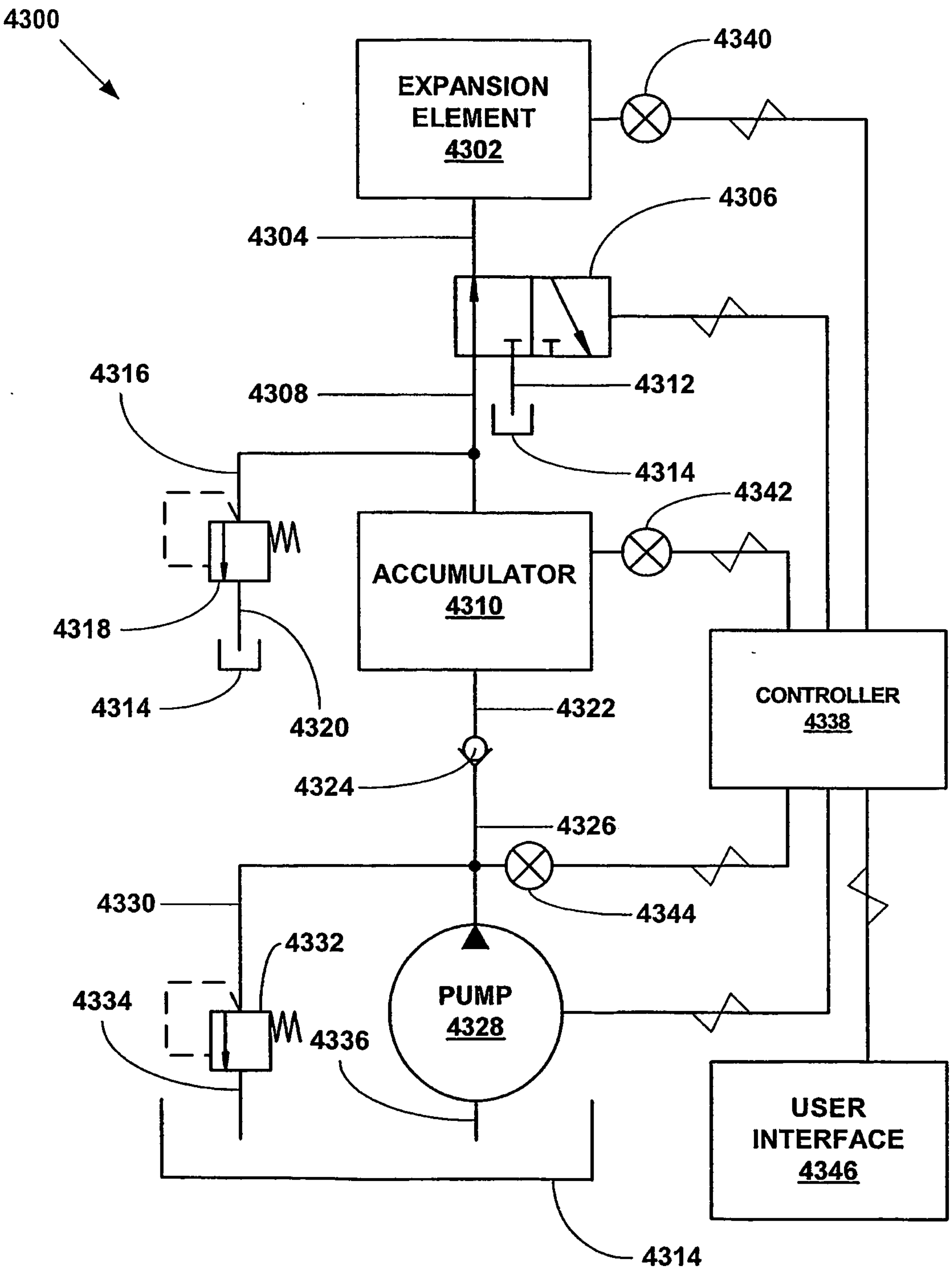
4300
EXPANSION ELEMENT 4302
4340
4306
4304
4316
4308
4312
4314
4342
ACCUMULATOR 4310
CONTROLLER 4338
4318
4314
4320
4322
4324
4326
4330
4344
4332
4334
PUMP 4328
4336
USER INTERFACE 4346
4314

FIG. 43

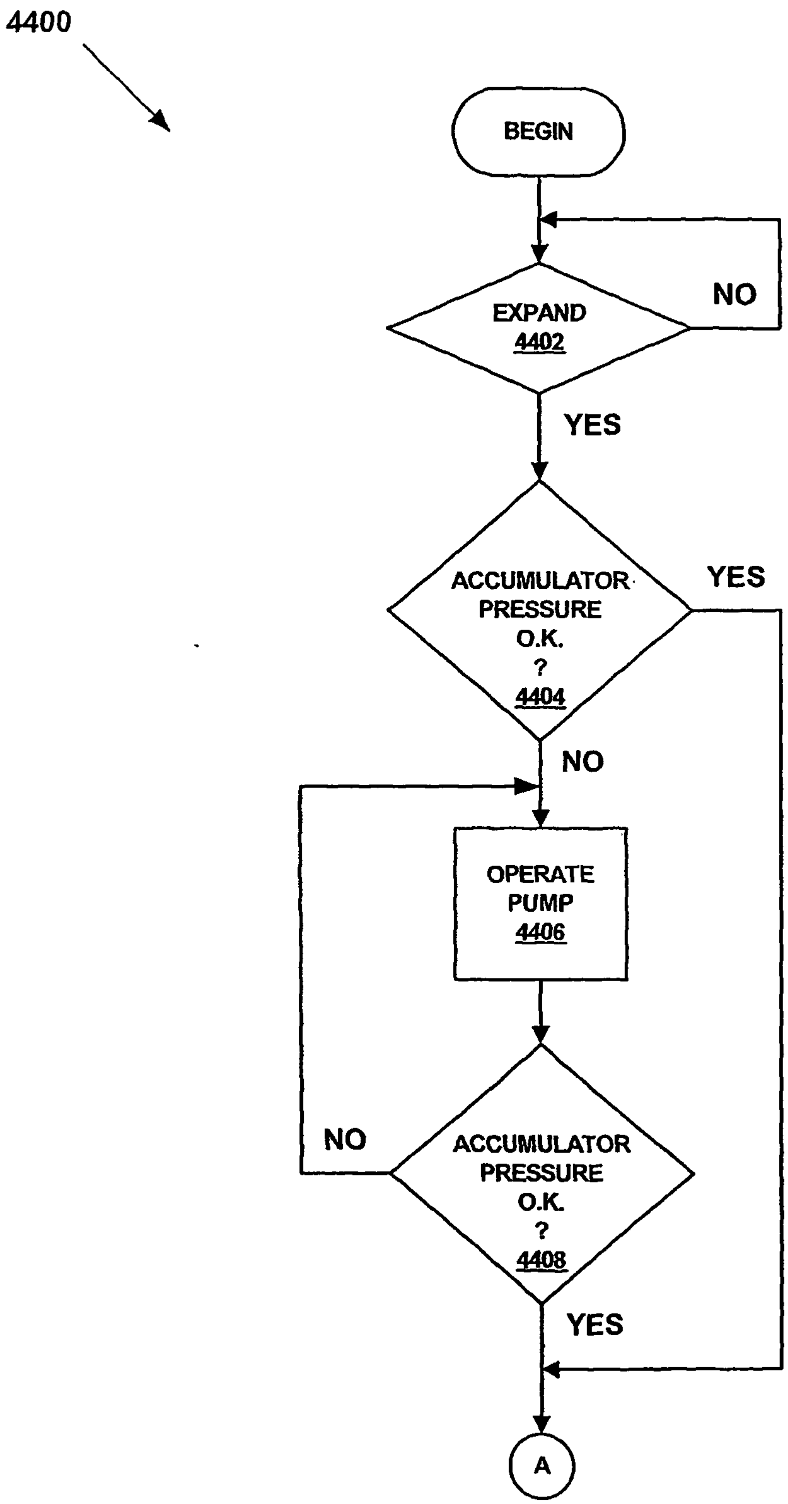
4400
BEGIN
EXPAND
4402
NO
YES
ACCUMULATOR PRESSURE O.K. ?
4404
YES
NO
OPERATE PUMP
4406
ACCUMULATOR PRESSURE O.K. ?
4408
NO
YES
A

FIG. 44a

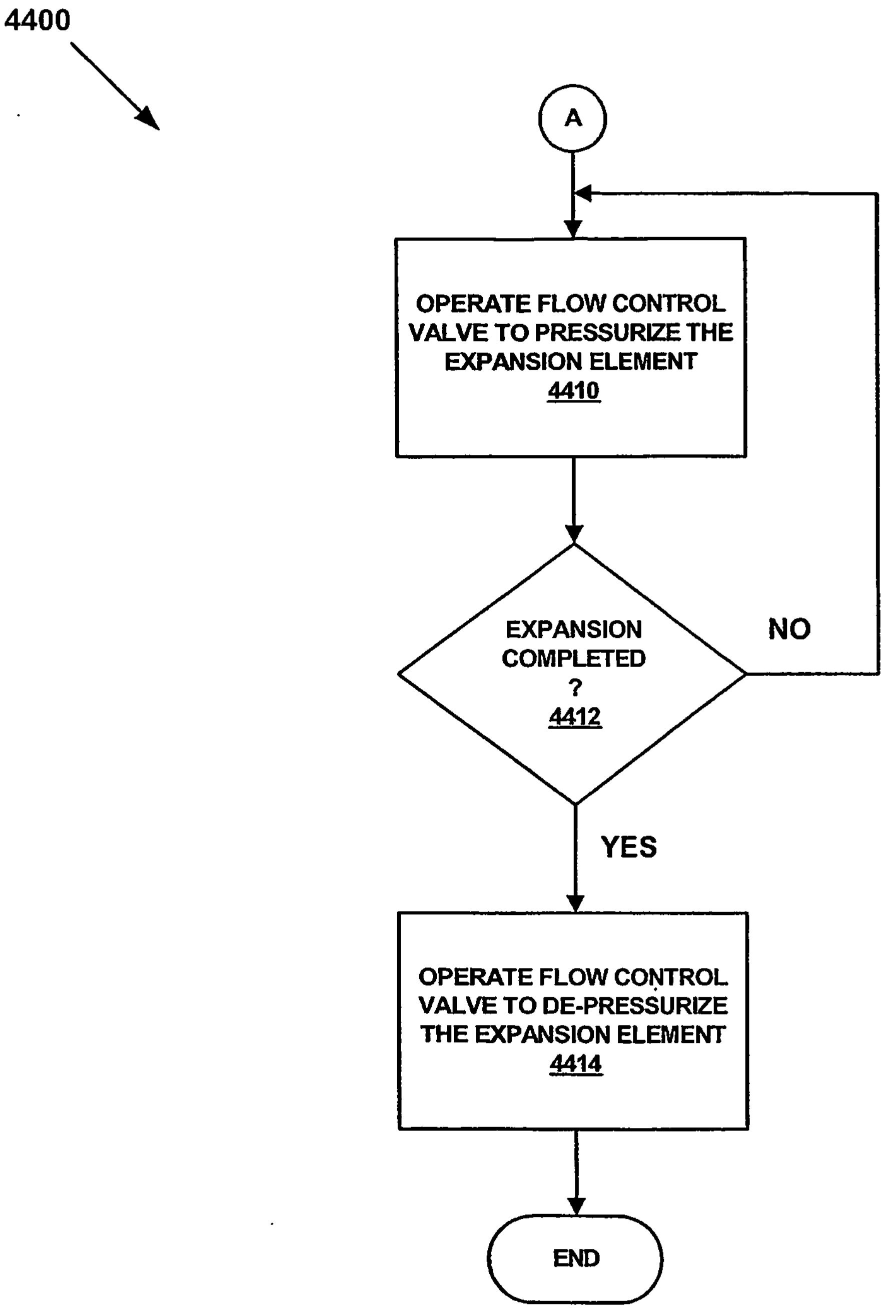
4400
A
OPERATE FLOW CONTROL VALVE TO PRESSURIZE THE EXPANSION ELEMENT
4410
EXPANSION COMPLETED ?
4412
NO
YES
OPERATE FLOW CONTROL VALVE TO DE-PRESSURIZE THE EXPANSION ELEMENT
4414
END

FIG. 44b

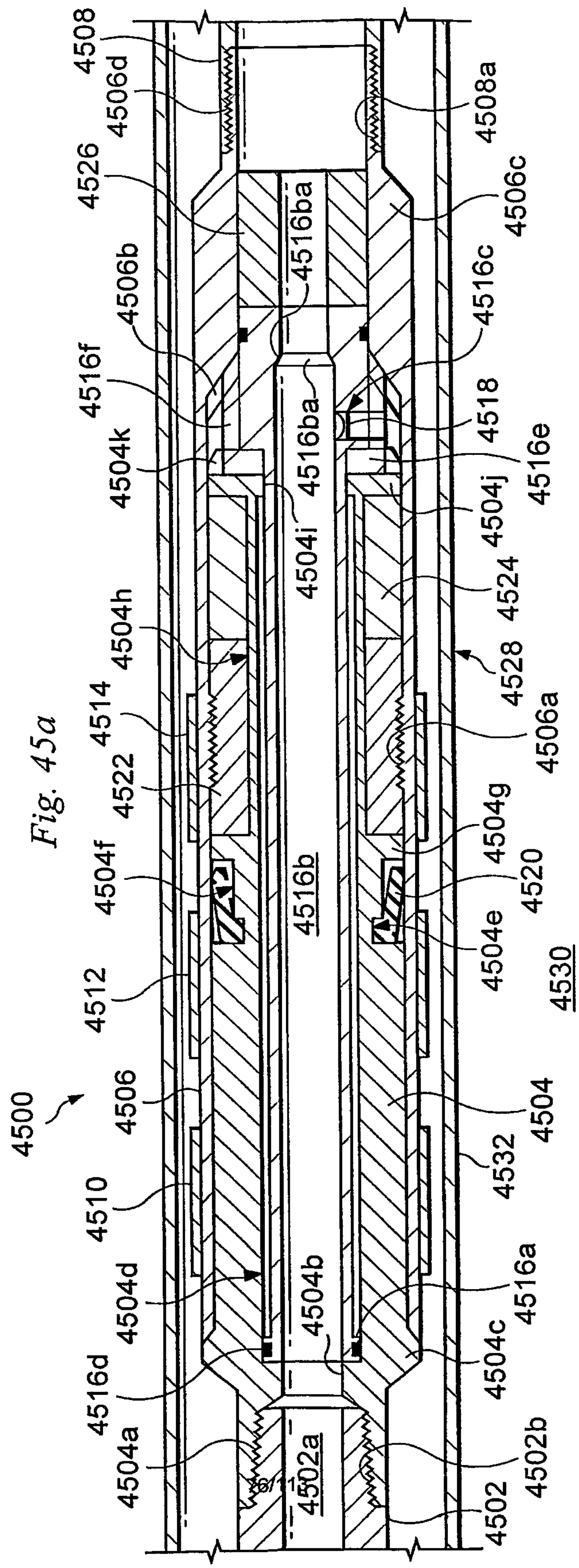
4500
4508
4506d
4508a
4526
4516ba
4506c
4506b
4516c
4516f
4518
4516ba
4504k
4516e
4504i
4504j
4524
4504h
4528
4514
4506a
4522
4504g
4504f
4516b
4520
4504e
4530
4512
4506
4504
4532
4510
4504d
4504b
4516a
4504c
4516d
4504a
4502a
4502b
4502

*Fig. 45a*

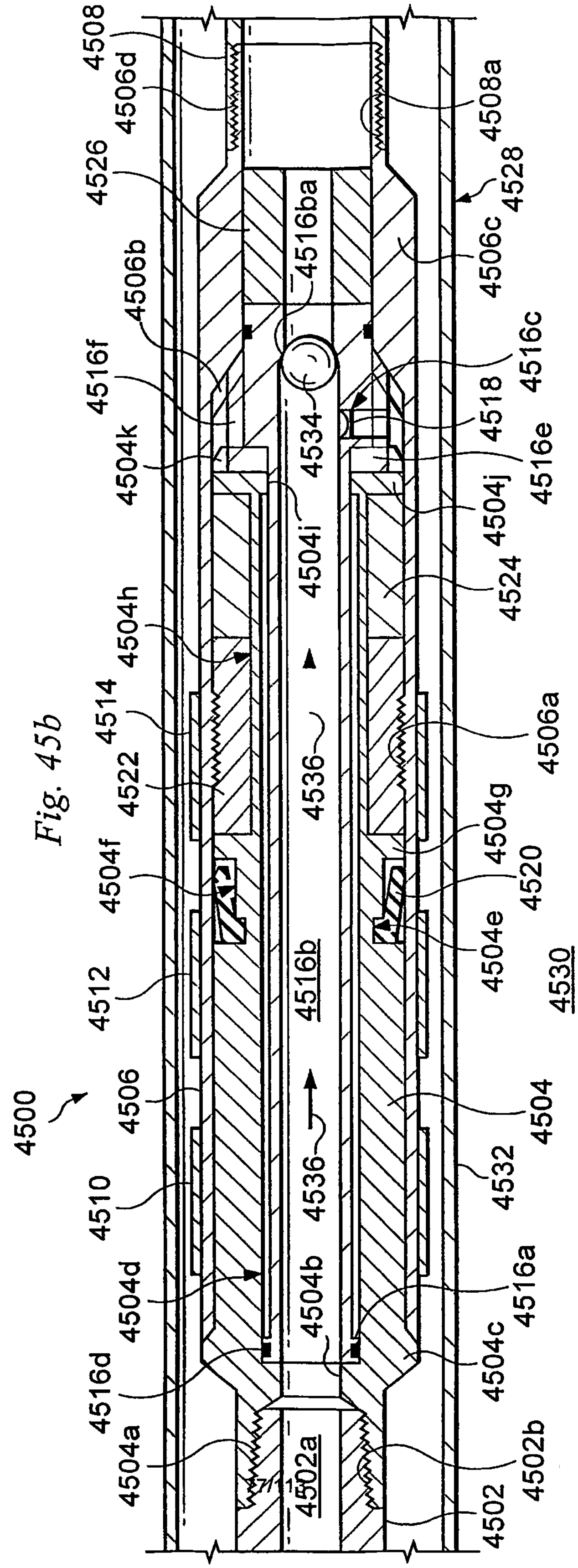
4500
4508
4506d
4526
4506b
4516f
4504k
4504h
4514
4522
4504f
4512
4506
4510
4504d
4516d
4504a
4516ba
4534
4504i
4536
4516b
4536
4504b
4502a
4508a
4528
4506c
4516c
4518
4516e
4504j
4524
4506a
4504g
4520
4504e
4530
4504
4532
4516a
4504c
4502b
4502

Fig. 45b

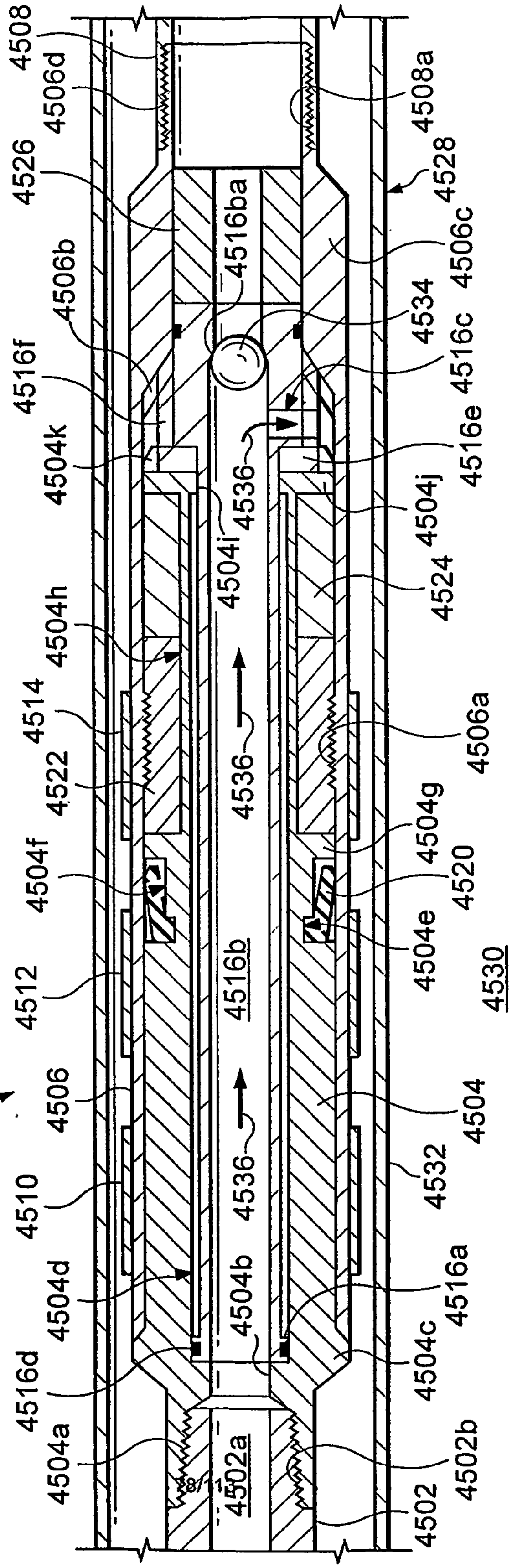
4500
4508
4506d
4526
4506b
4516f
4504k
4504h
4514
4522
4504f
4512
4506
4510
4504d
4516d
4504a
4508a
4528
4506c
4516ba
4534
4516c
4516e
4536
4504i
4504j
4524
4506a
4504g
4520
4504e
4516b
4530
4504
4532
4504b
4516a
4504c
4502a
4502b
4502

*Fig. 45c*

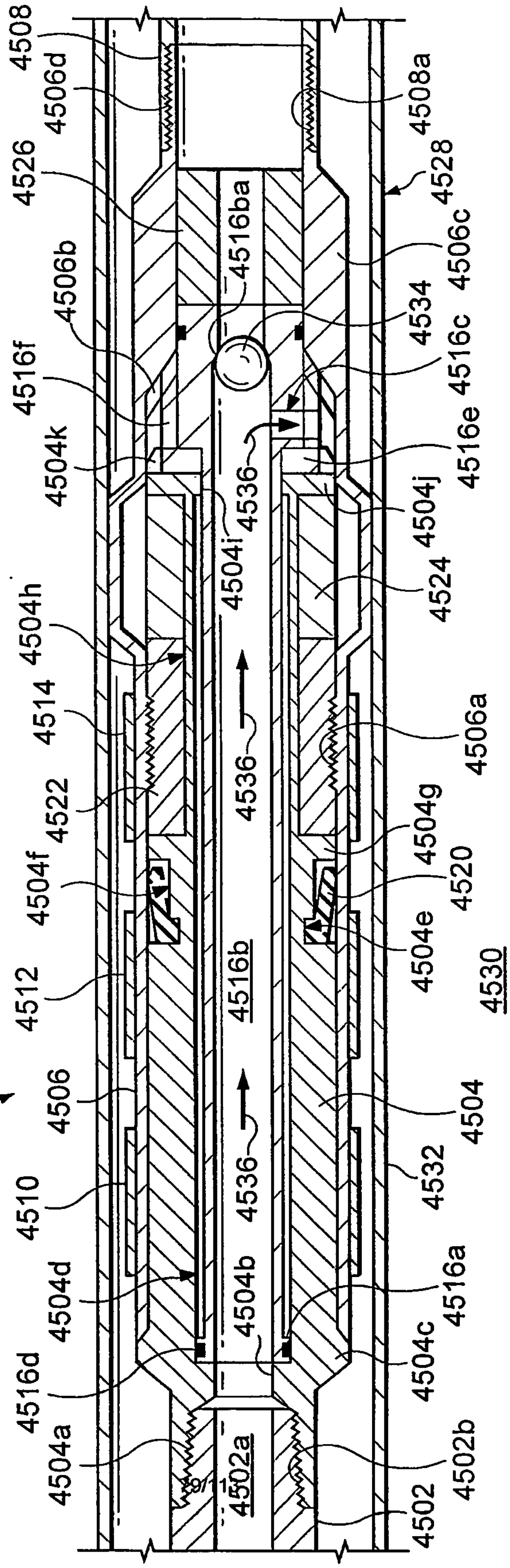
4500
4508
4506d
4526
4506b
4516f
4504k
4504h
4514
4522
4504f
4512
4506
4510
4504d
4516d
4504a
4516ba
4534
4536
4504i
4536
4516b
4536
4504b
4502a
4508a
4528
4506c
4516c
4516e
4504j
4524
4506a
4504g
4520
4504e
4530
4504
4532
4516a
4504c
4502b
4502

Fig. 45d

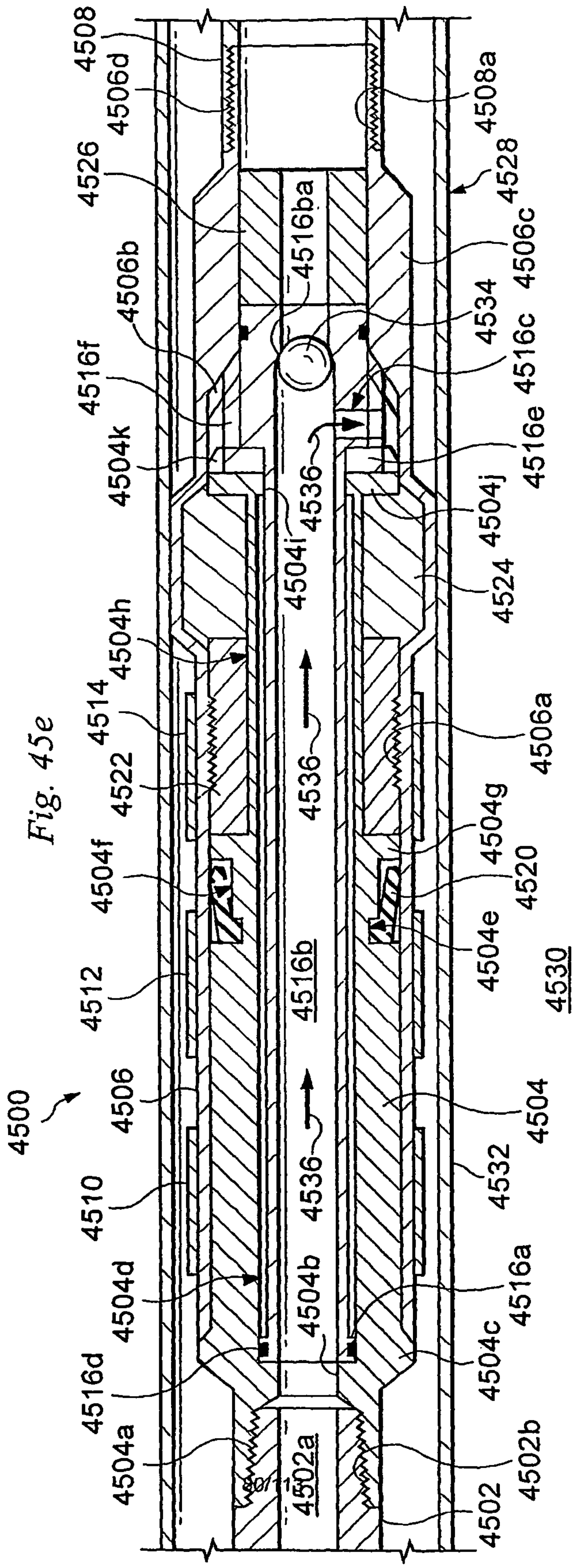
4500
4502
4502a
4502b
4504
4504a
4504b
4504c
4504d
4504e
4504f
4504g
4504h
4504i
4504j
4504k
4506
4506a
4506b
4506c
4506d
4508
4508a
4510
4512
4514
4516a
4516b
4516ba
4516c
4516d
4516e
4516f
4520
4522
4524
4526
4528
4530
4532
4534
4536

*Fig. 45e*

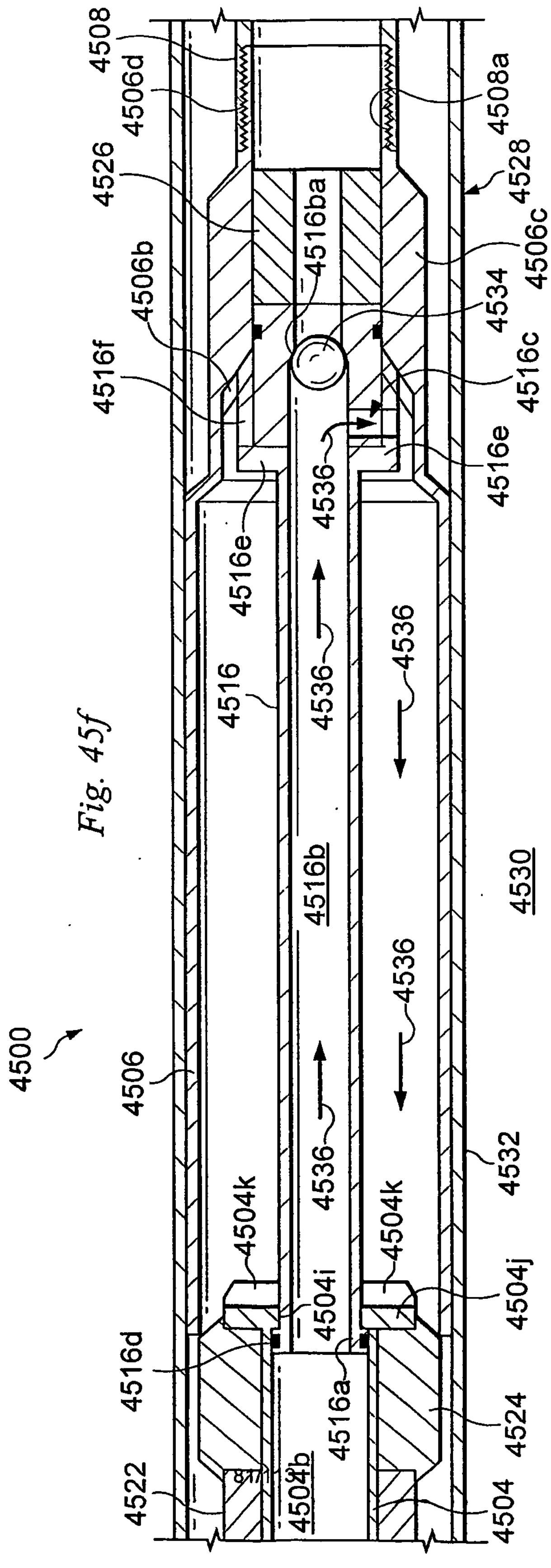
4500
4508
4506d
4508a
4526
4528
4516ba
4506c
4506b
4534
4516f
4516c
4516e
4536
4516e
4516
4536
4536
4516b
4530
4536
4506
4536
4532
4504k
4504k
4504i
4504j
4516d
4516a
4524
4522
4504b
4504

Fig. 45f

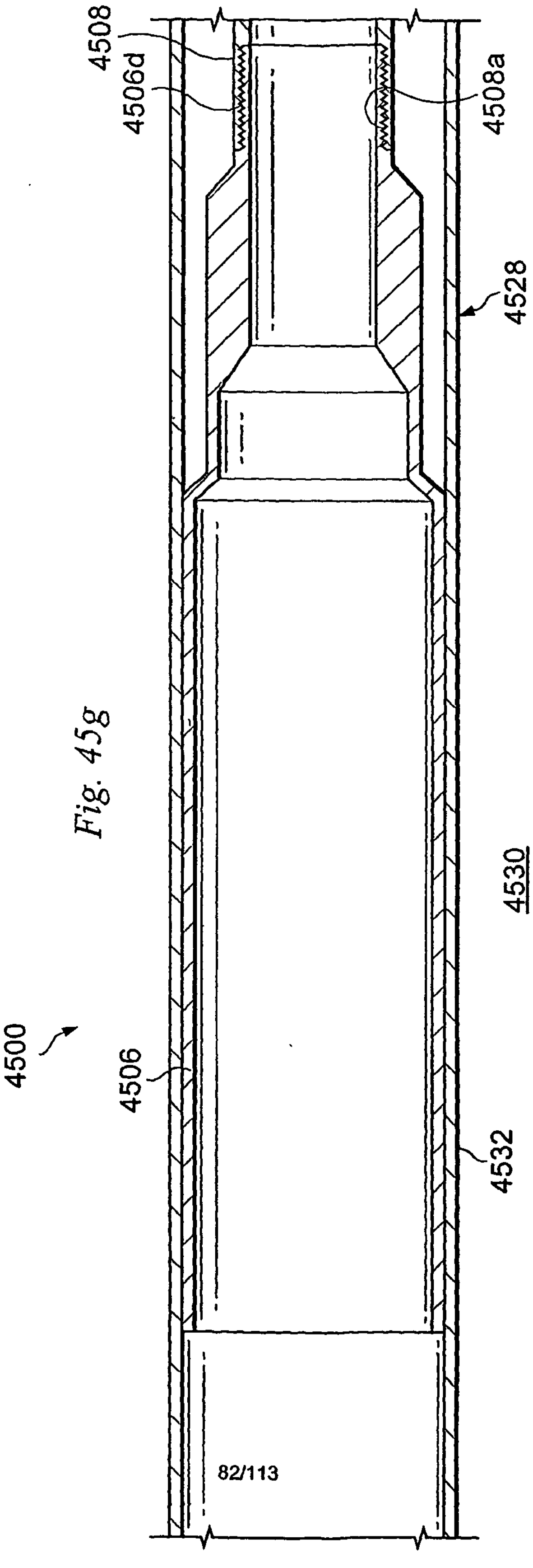

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Fig. 45g

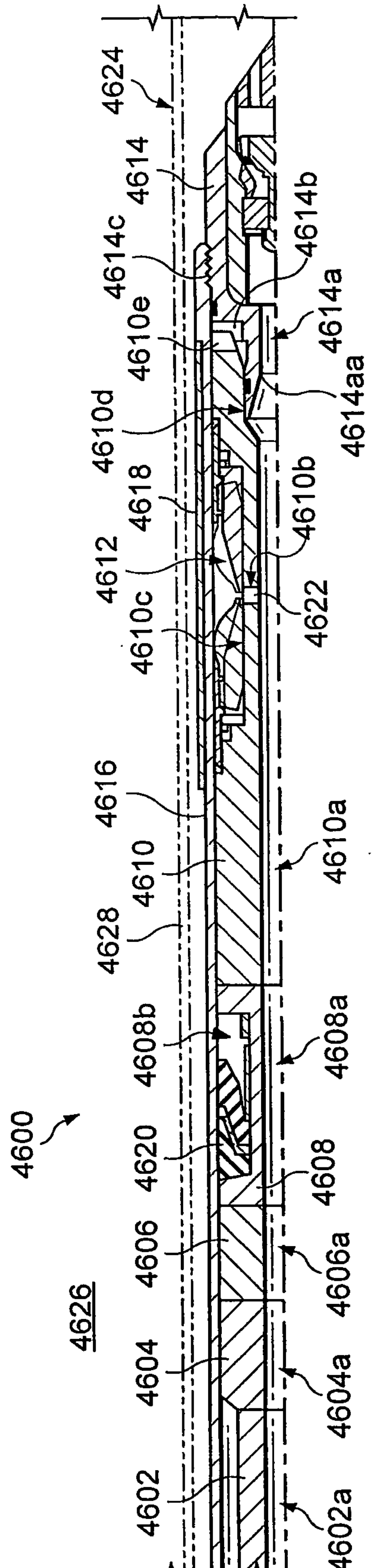



Fig. 46a

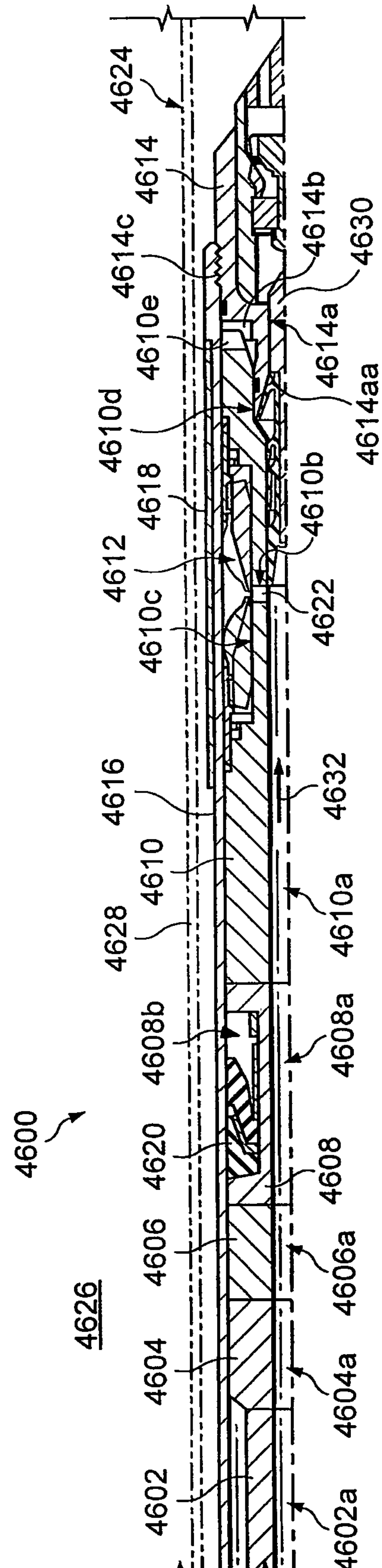



Fig. 46b

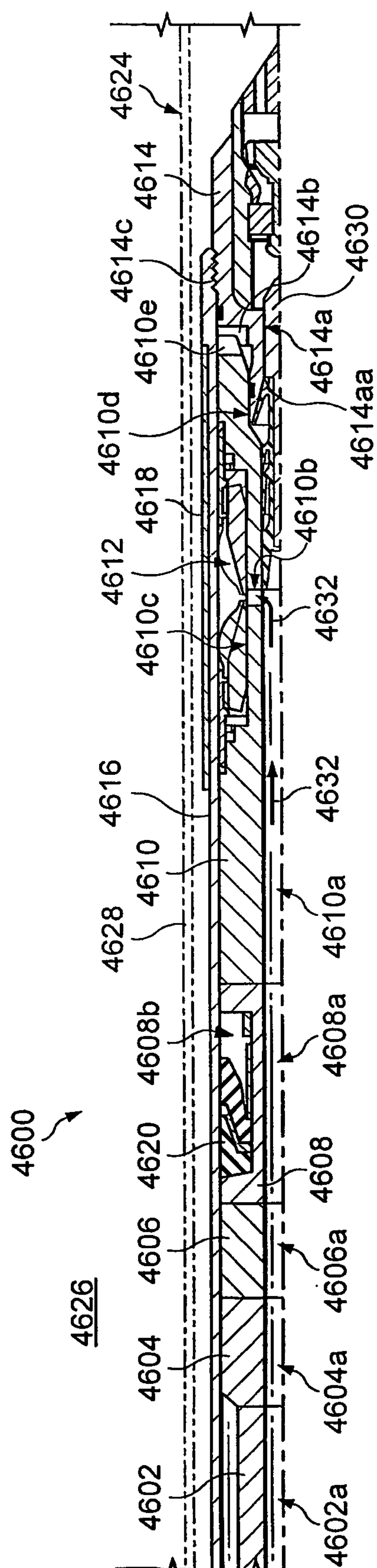



*Fig. 46c*

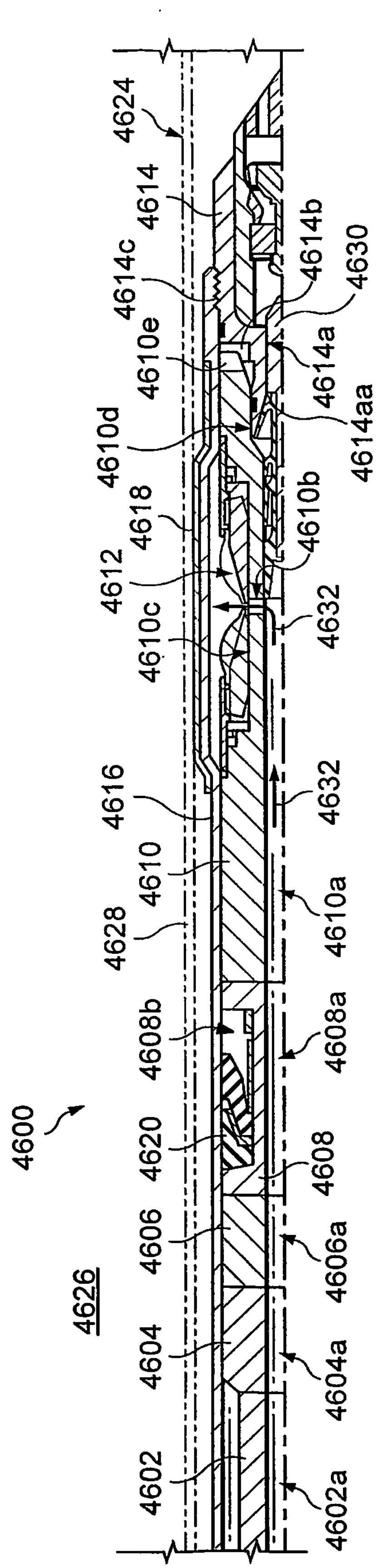



*Fig. 46d*

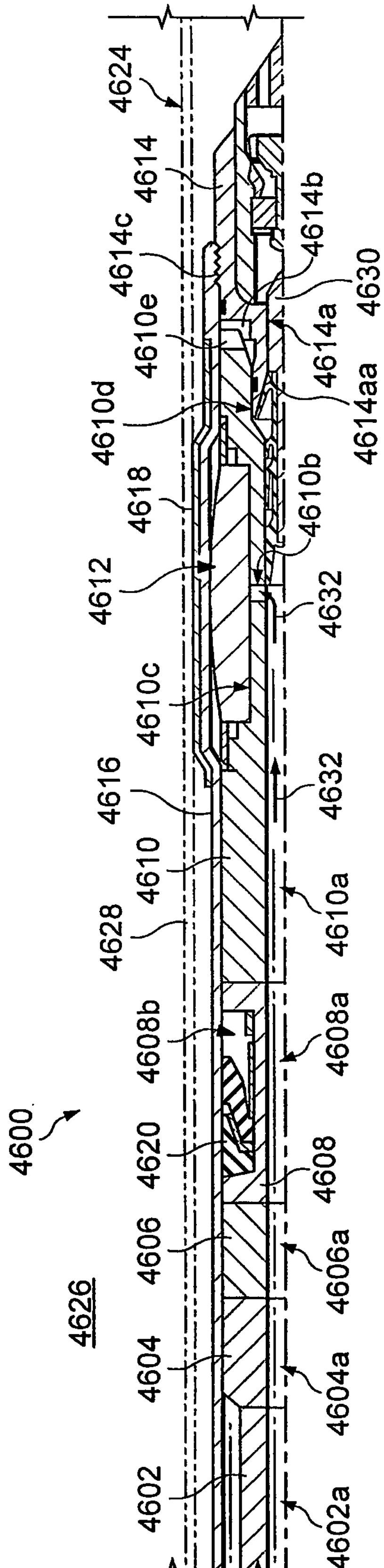



*Fig. 46e*

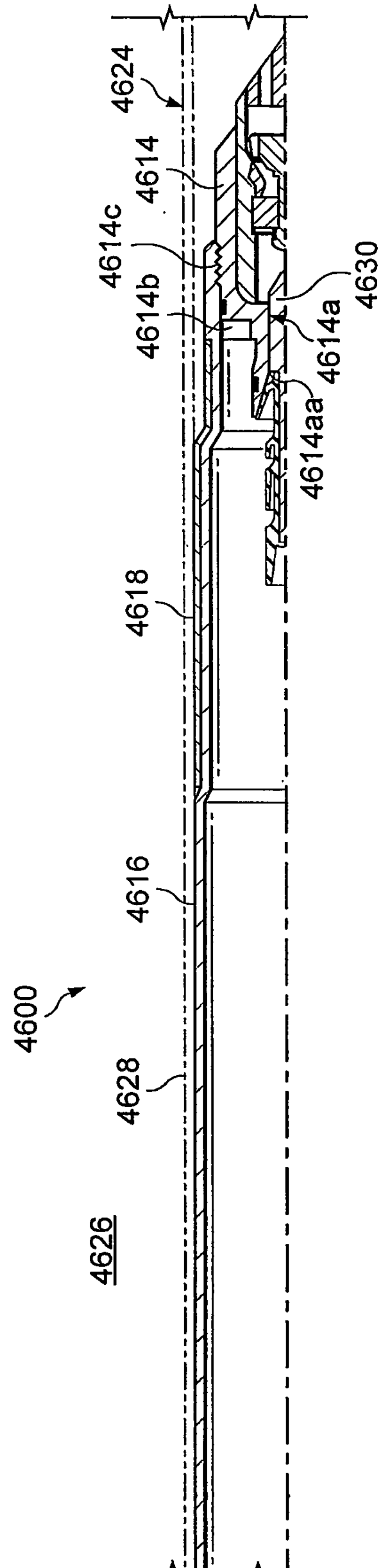



*Fig. 46f*

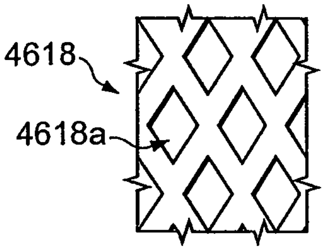



*Fig. 46g*

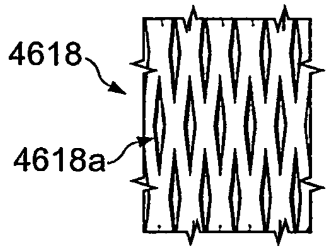



*Fig. 46h*

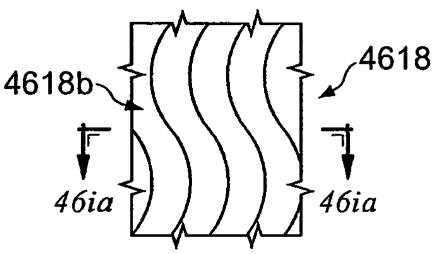



*Fig. 46i*

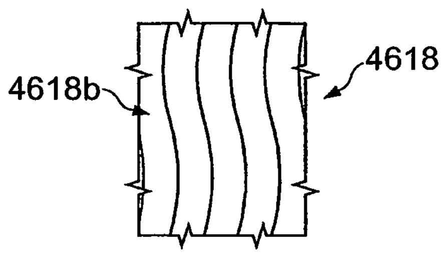



*Fig. 46j*

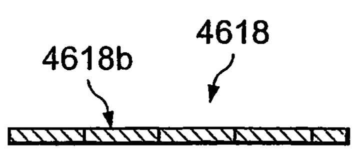



*Fig. 46ia*

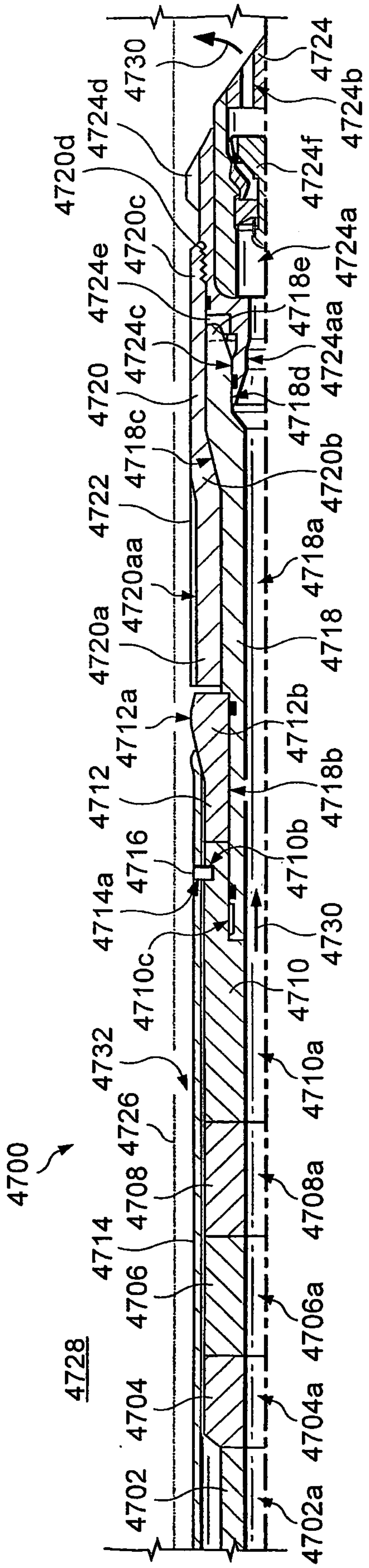



*Fig. 47a*

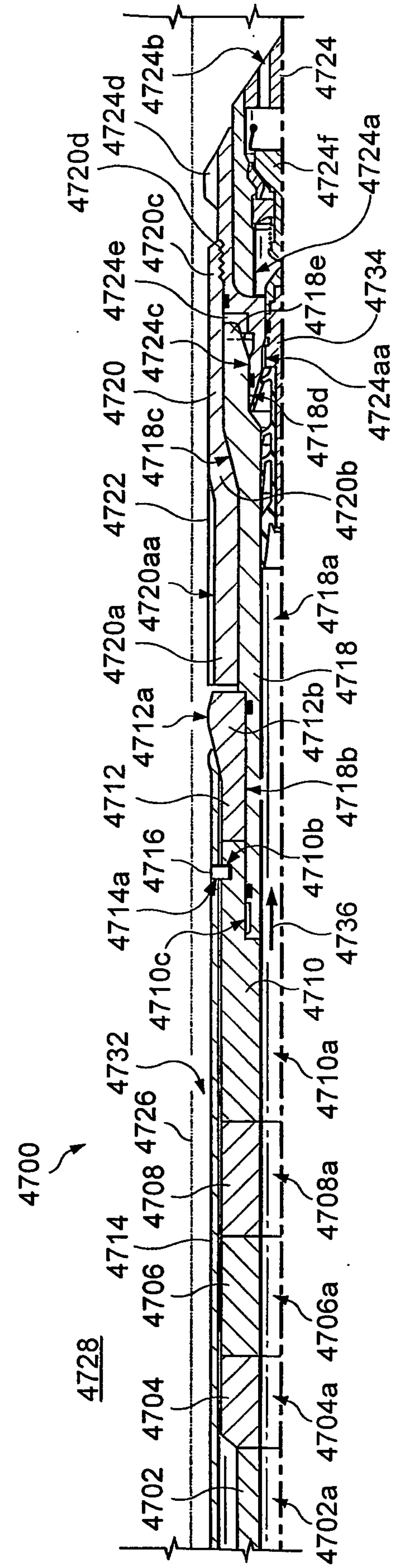



*Fig. 47b*

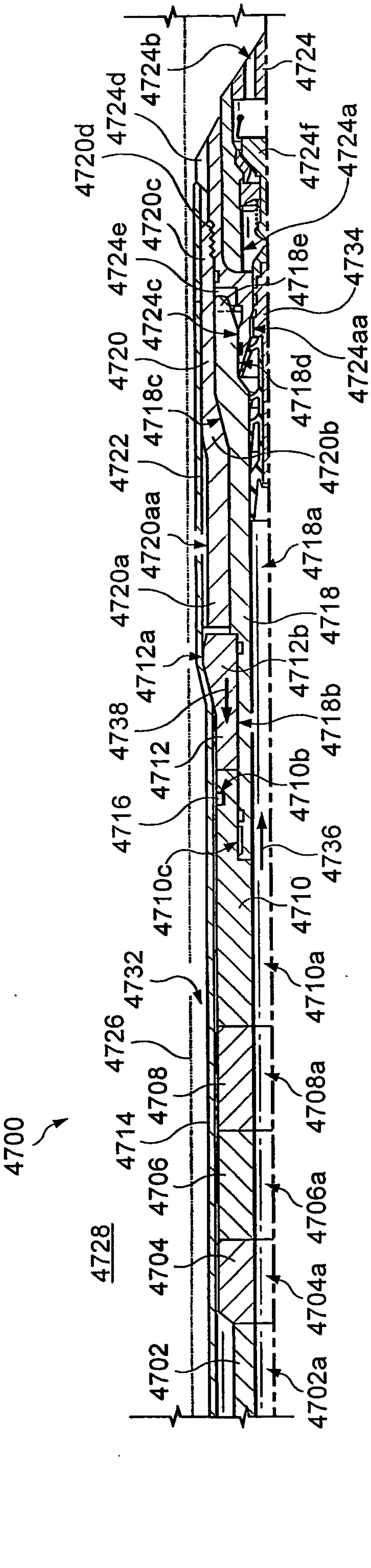



Fig. 47c

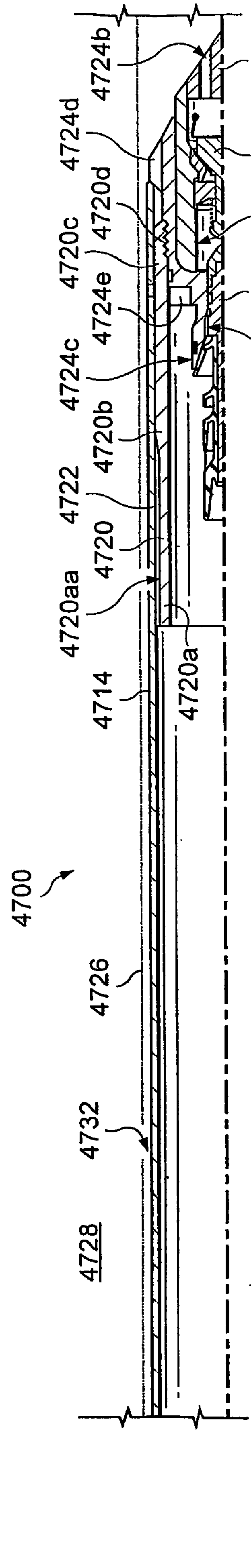
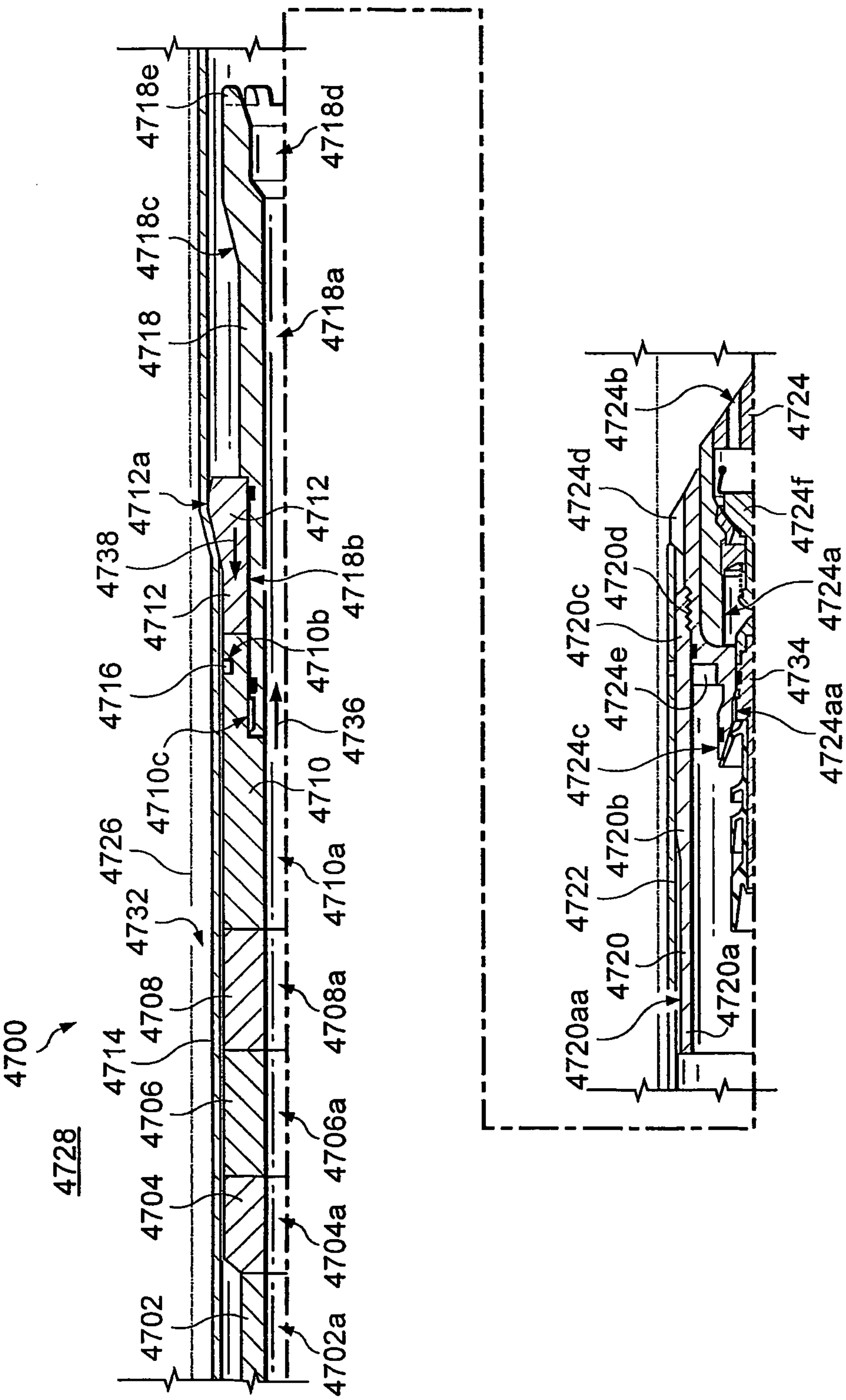



Fig. 47e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4724a
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4724aa

*Fig. 47d*

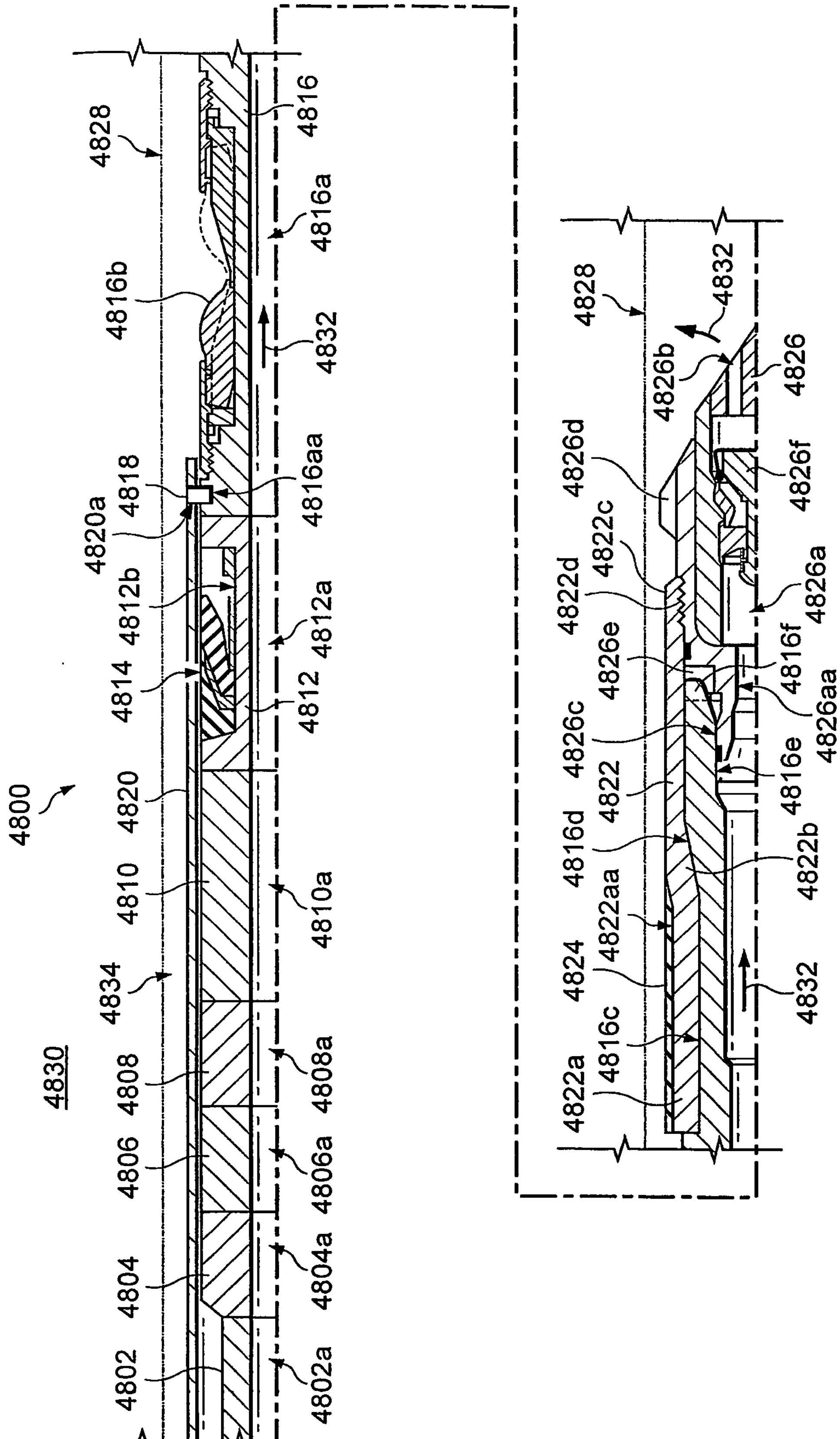
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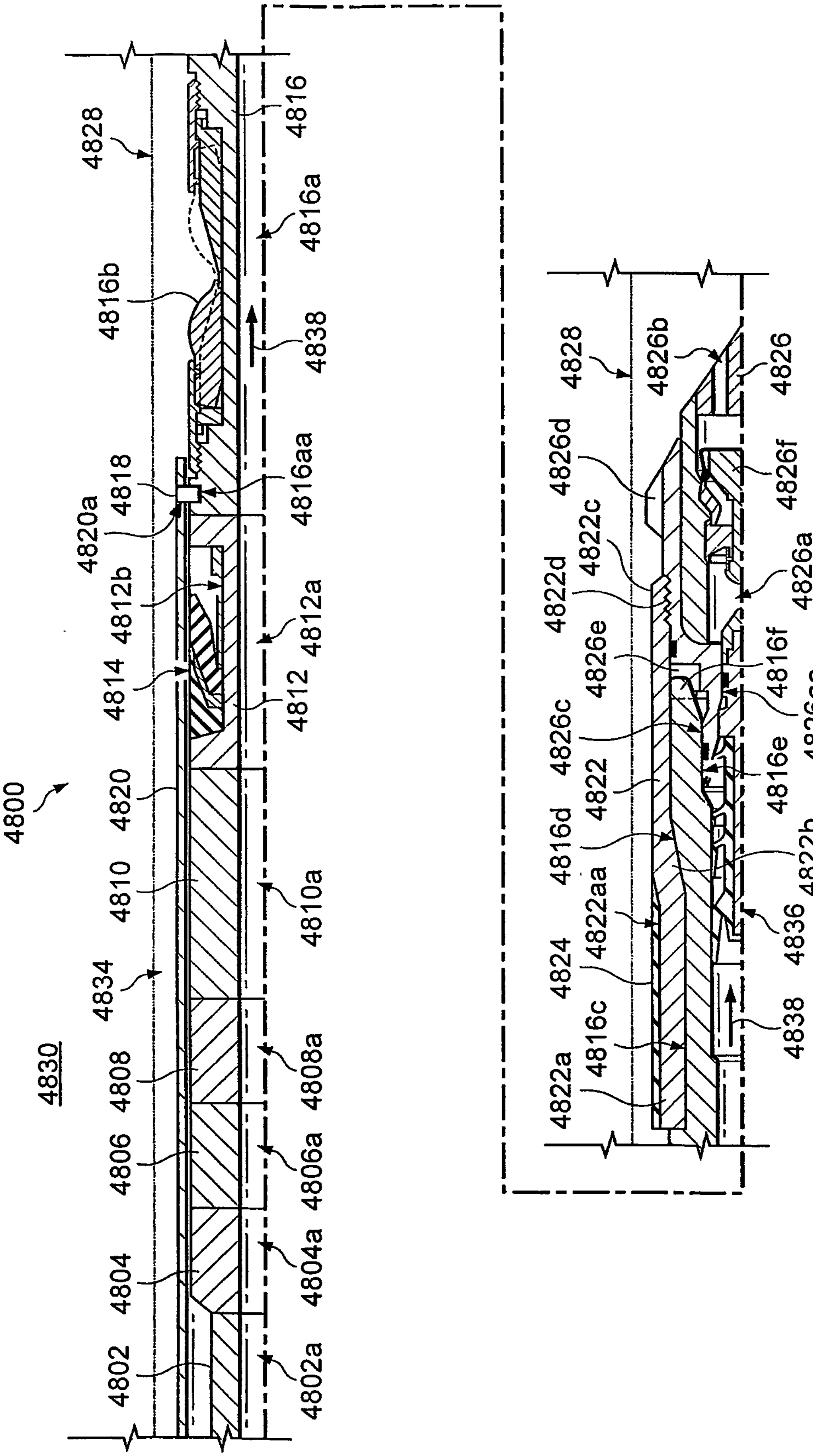
Fig. 48a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4826a
4826e
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4816c
4822a

Fig. 48b

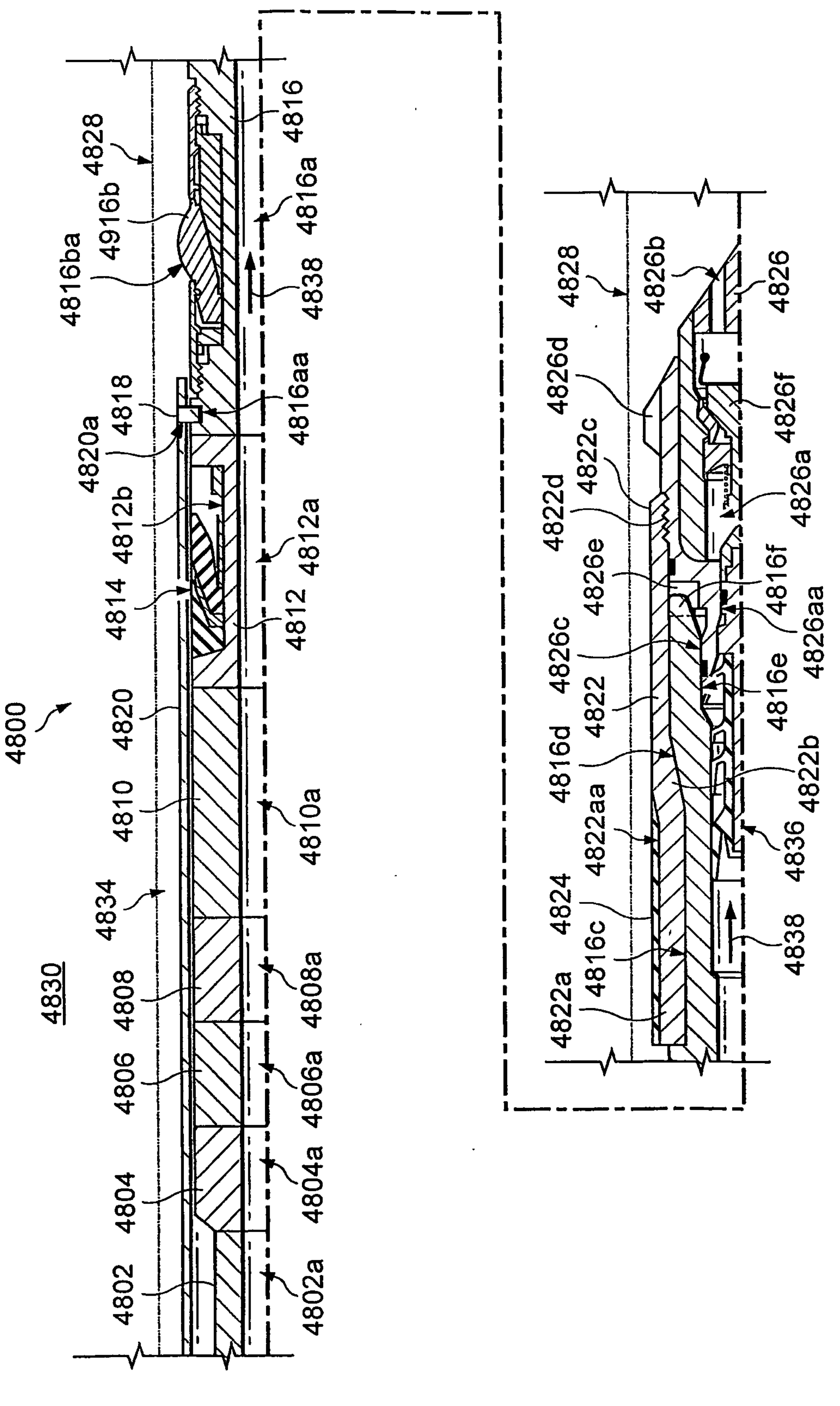
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Fig. 48c

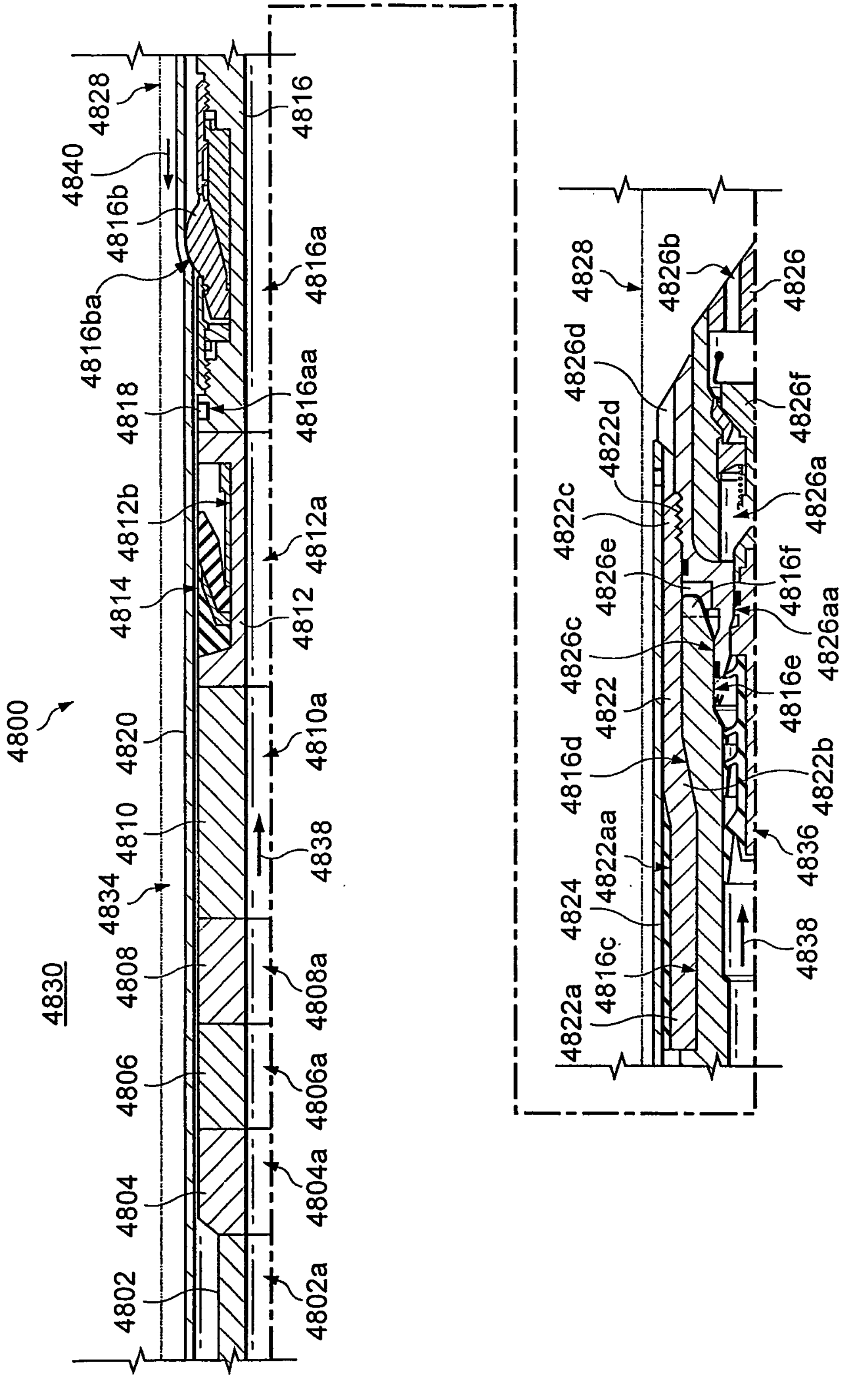

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Fig. 48d

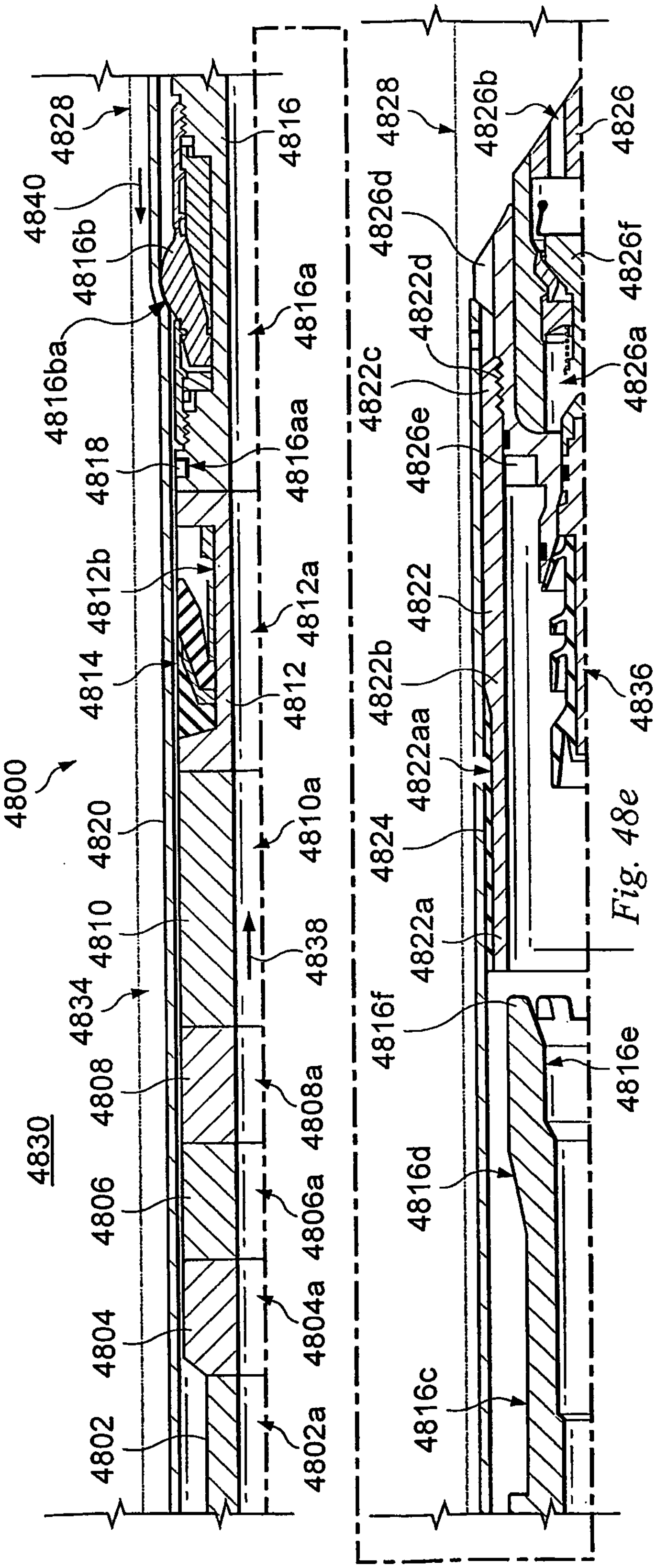



*Fig. 48e*

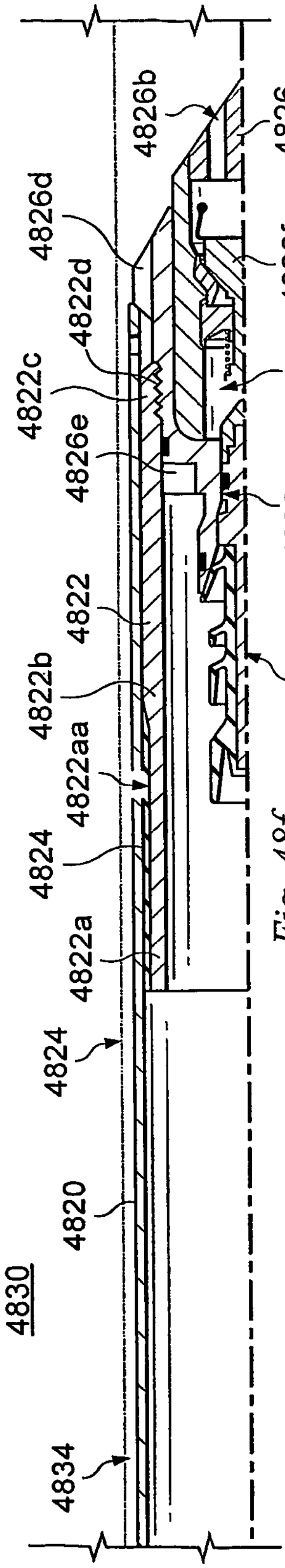
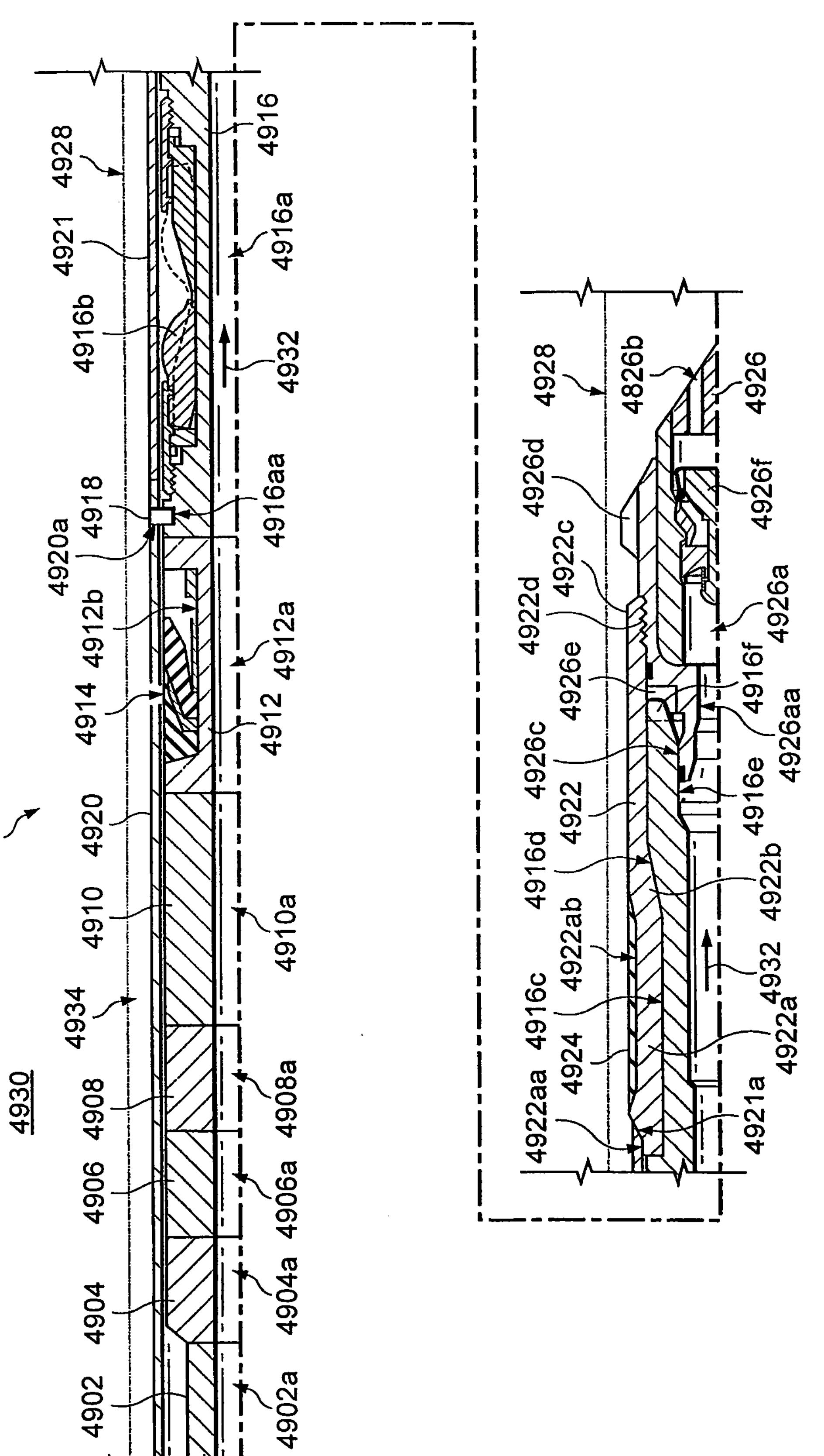



*Fig. 48f*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4922aa
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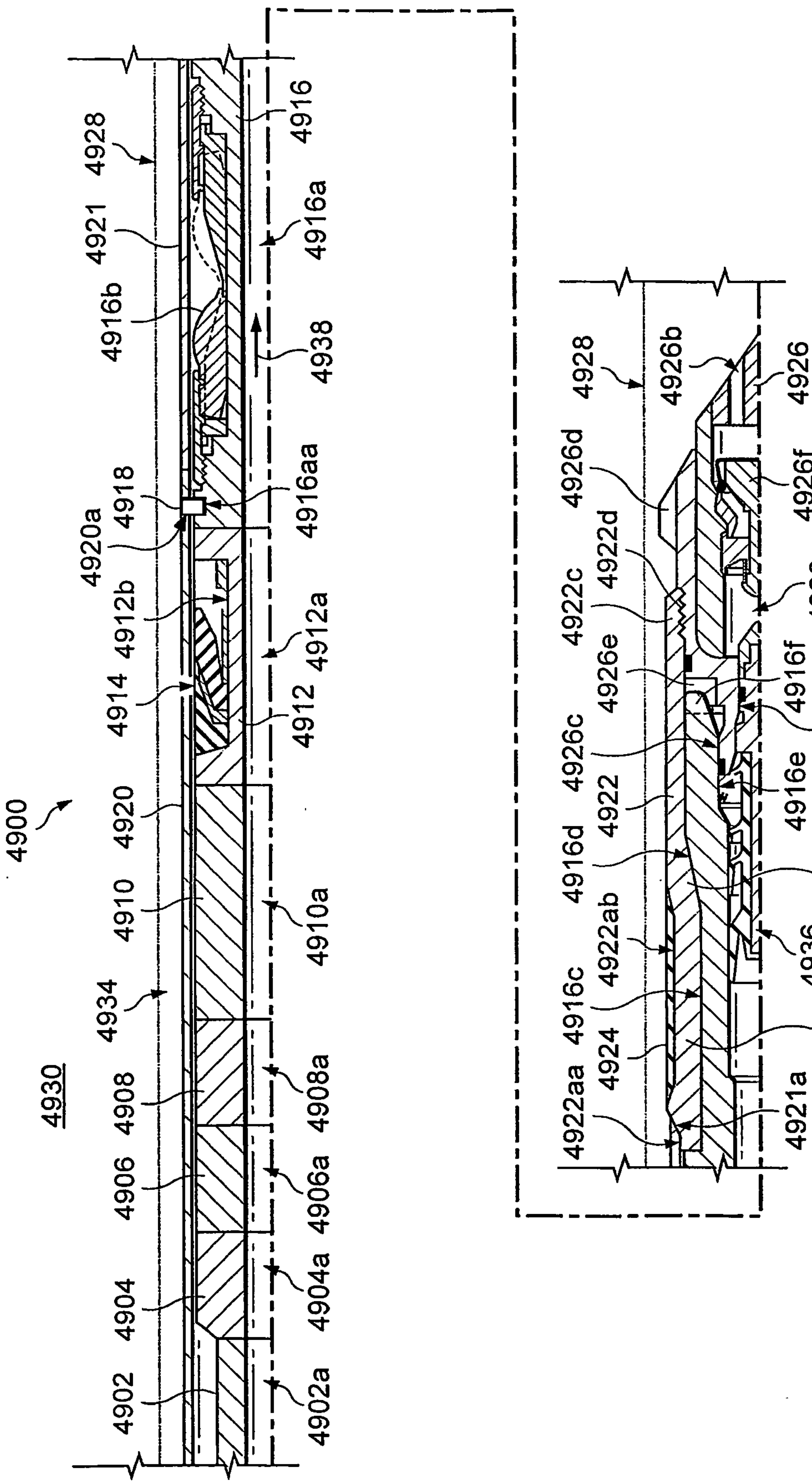
Fig. 49a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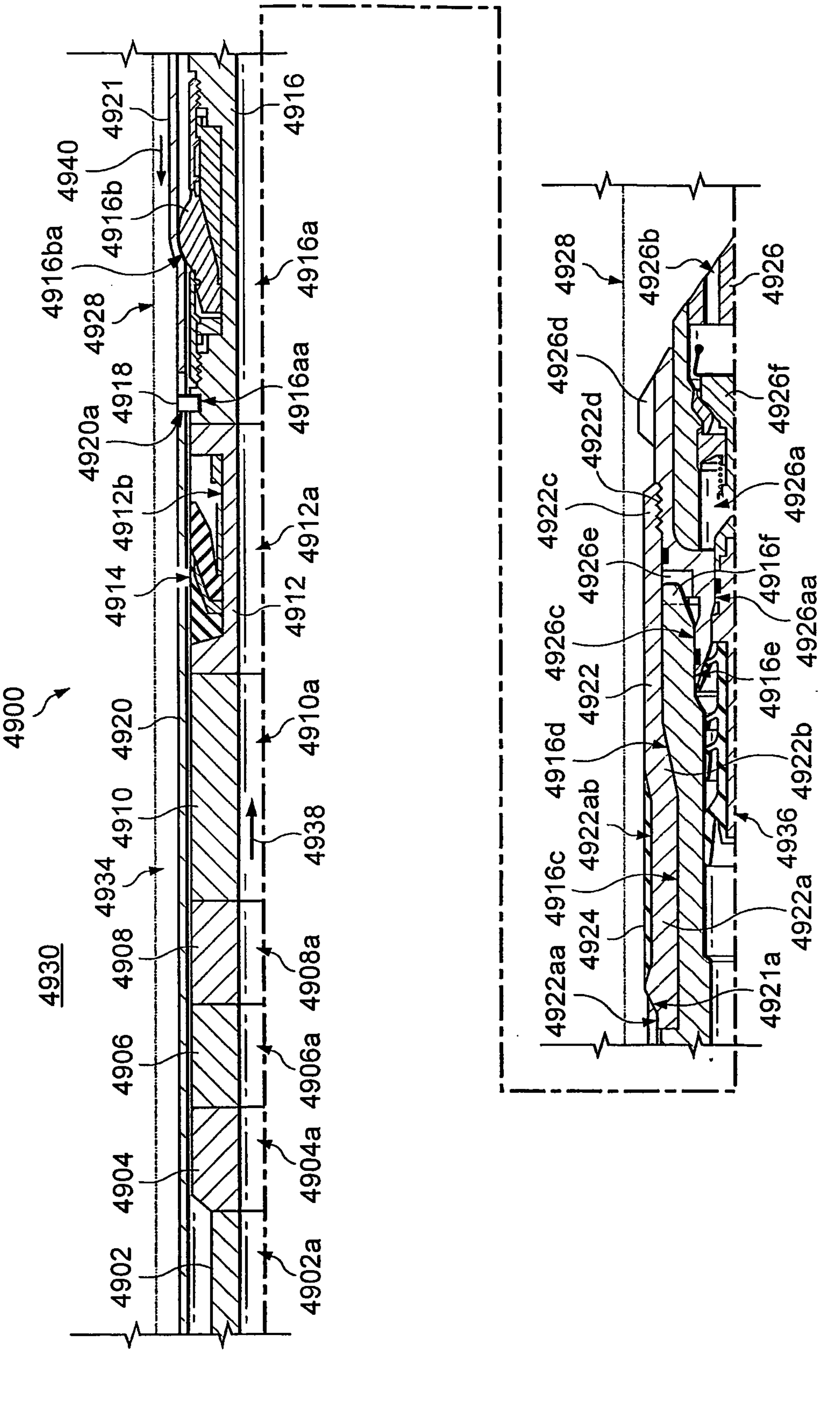
4921a

Fig. 49b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4926aa
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Fig. 49c

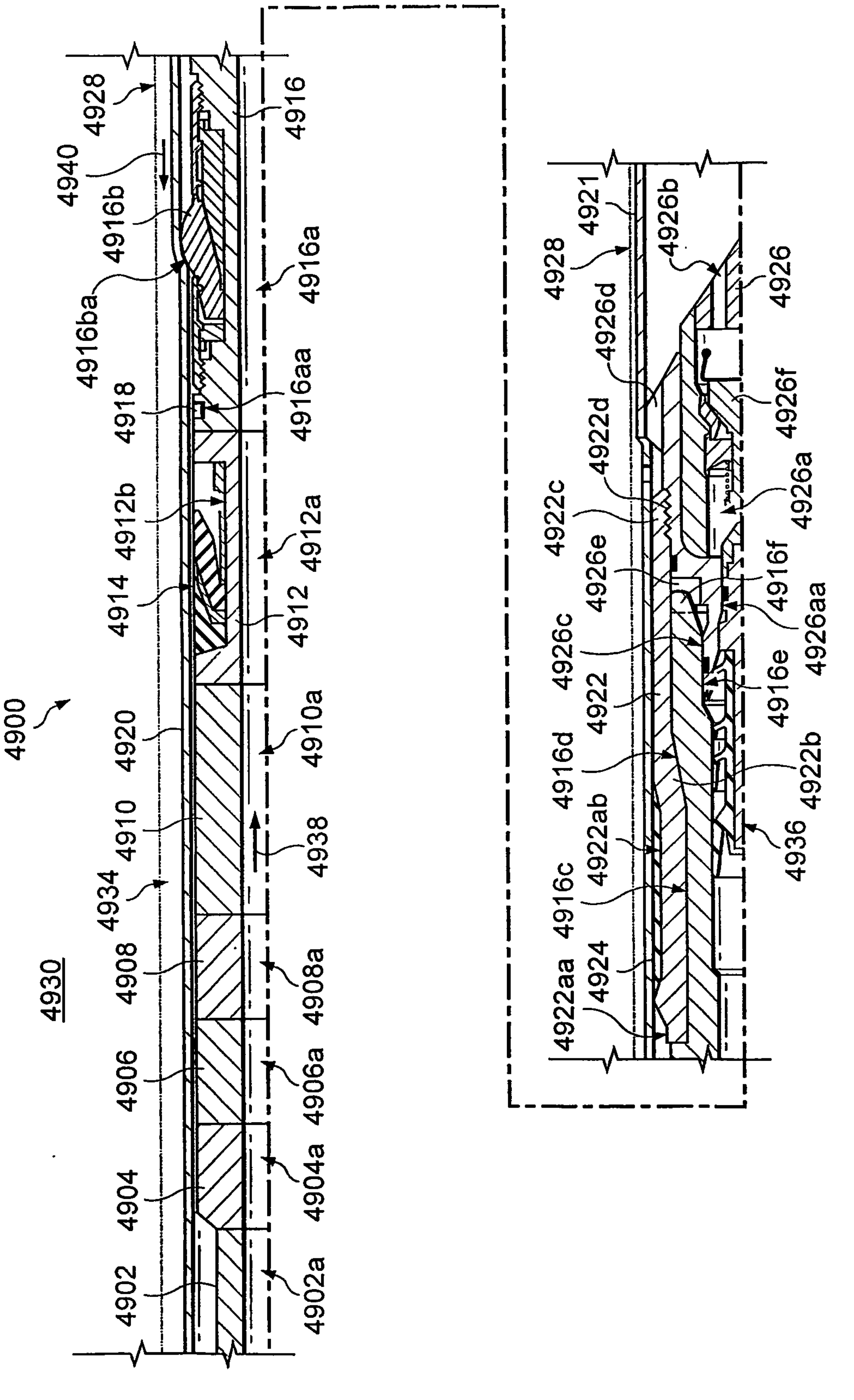
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Fig. 49d

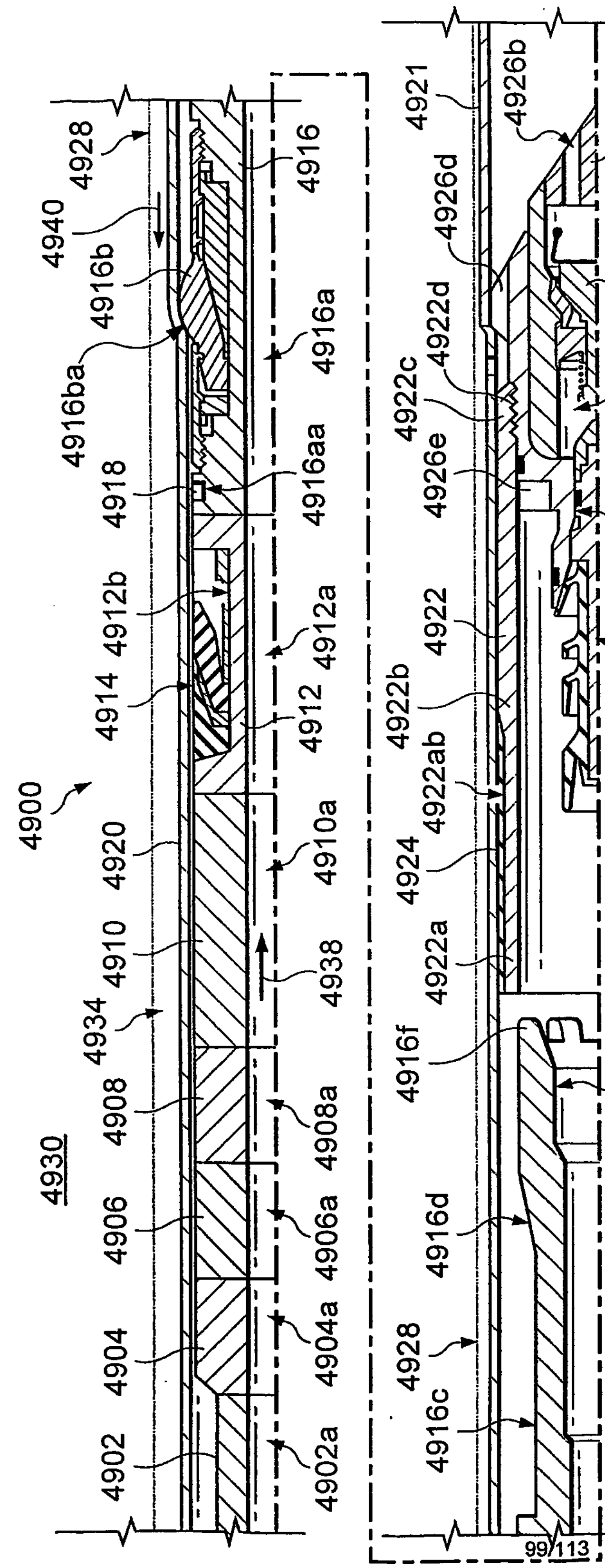



Fig. 49e

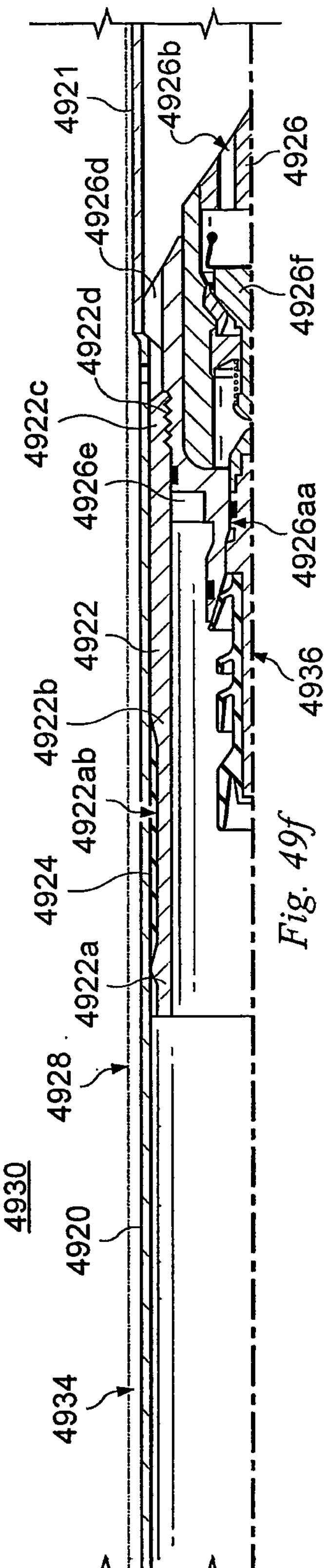
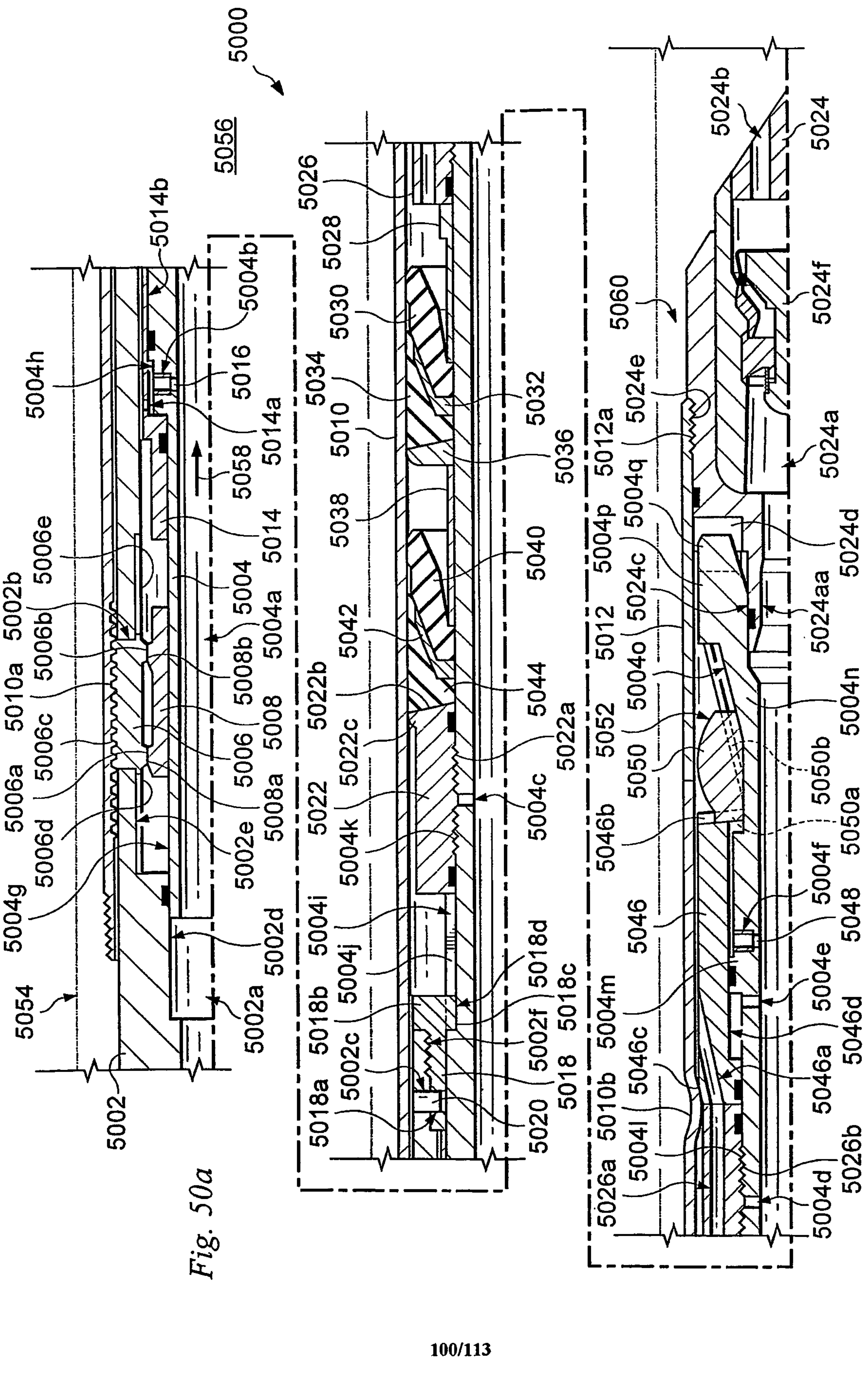



Fig. 49f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5004j
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5004f
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5004d

*Fig. 50a*

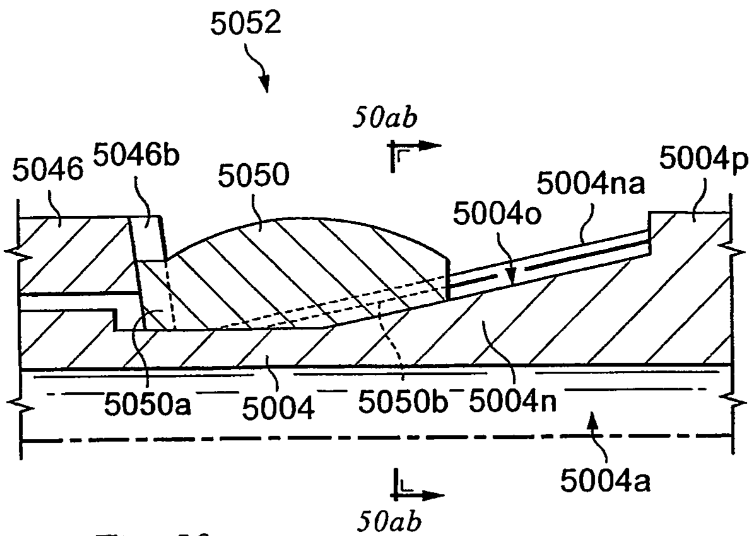


*Fig. 50aa*

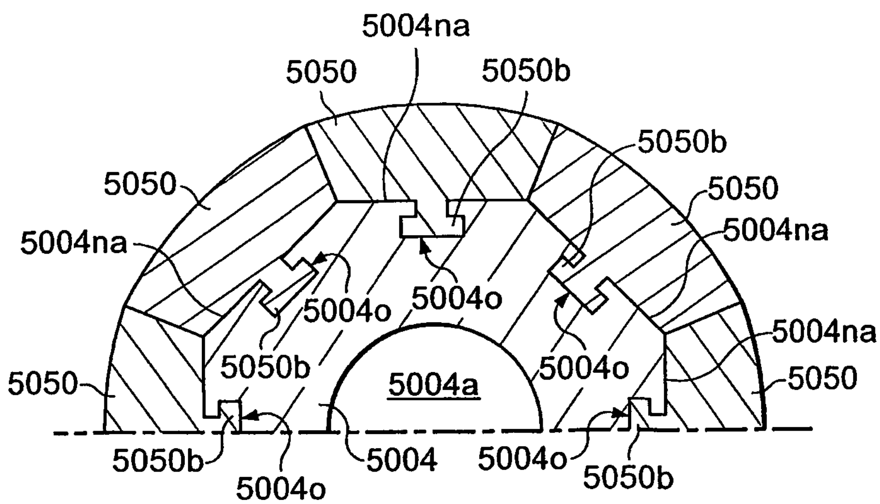


*Fig. 50ab*

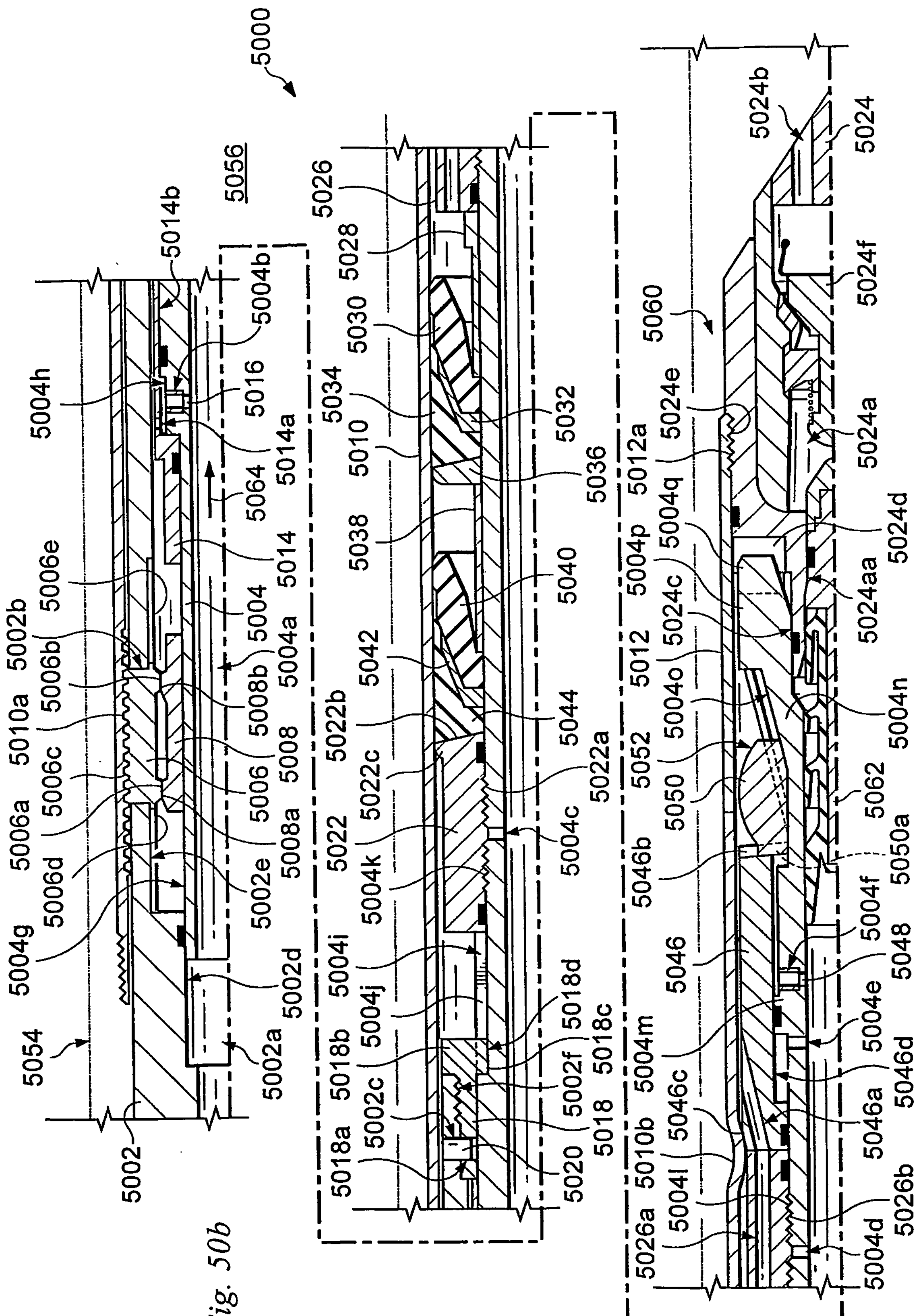
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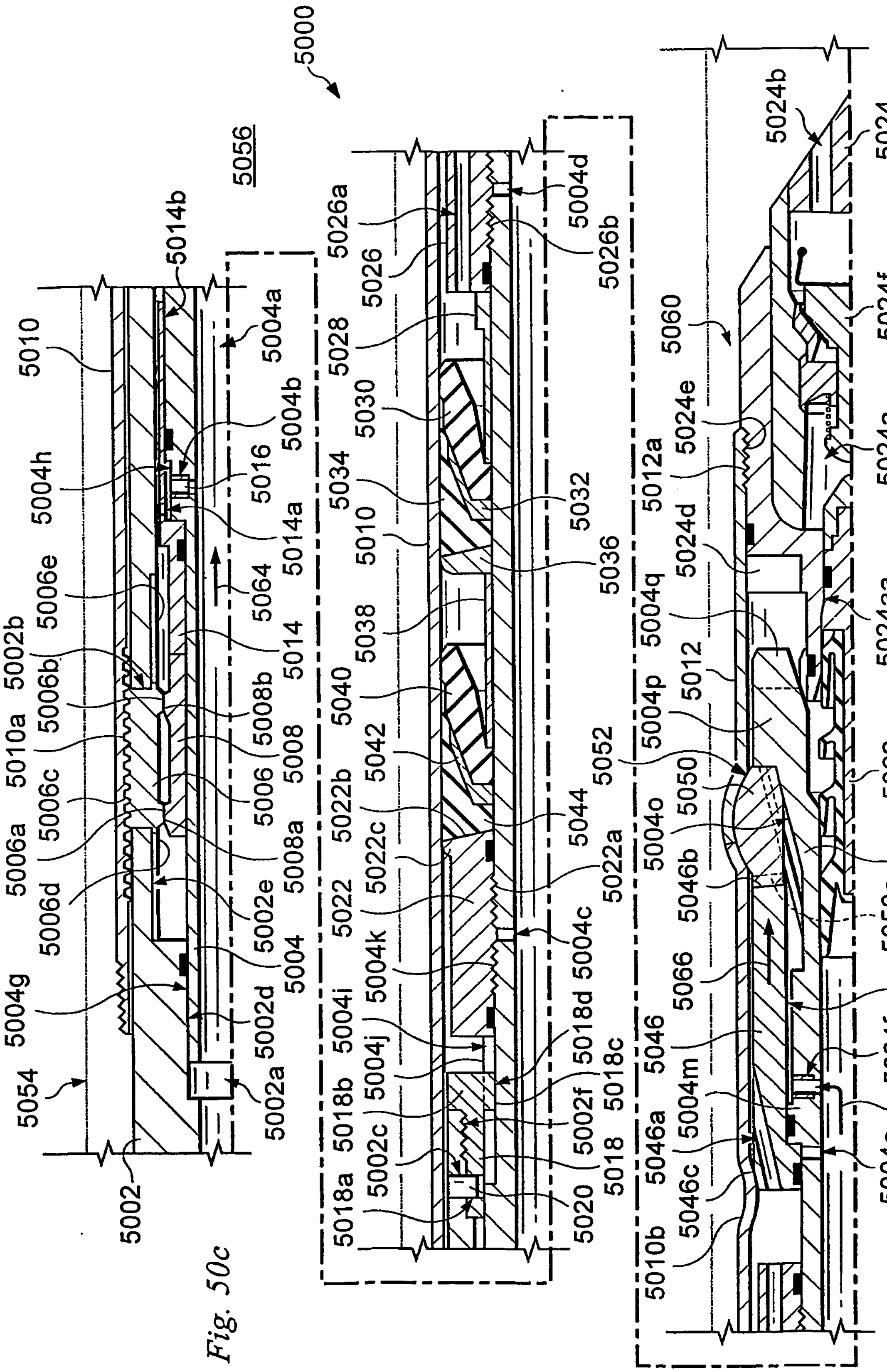
*Fig. 50b*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5010b

*Fig. 50c*

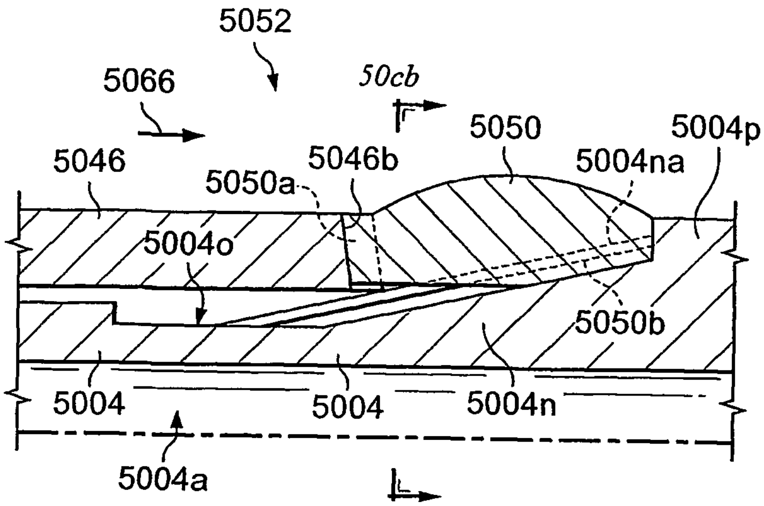


Fig. 50ca

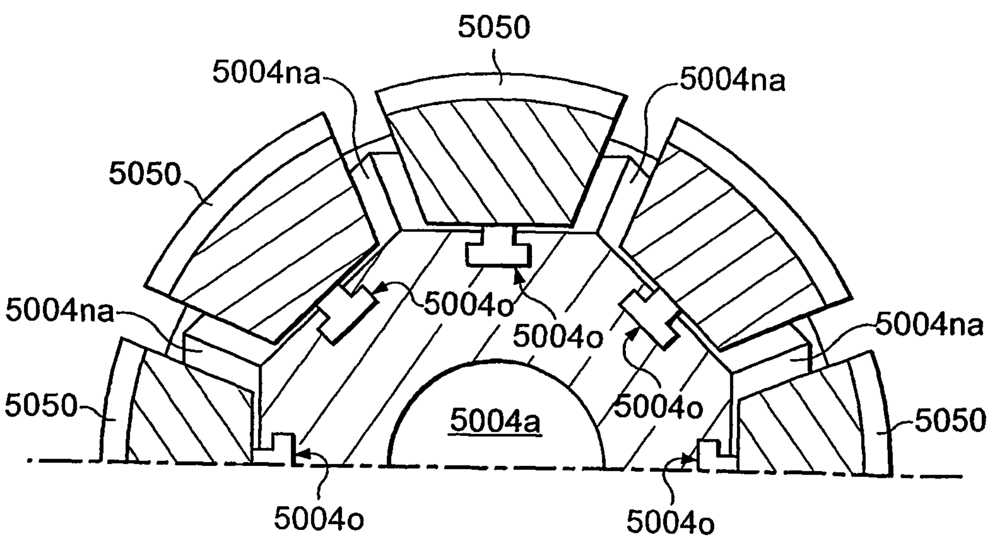


Fig. 50cb

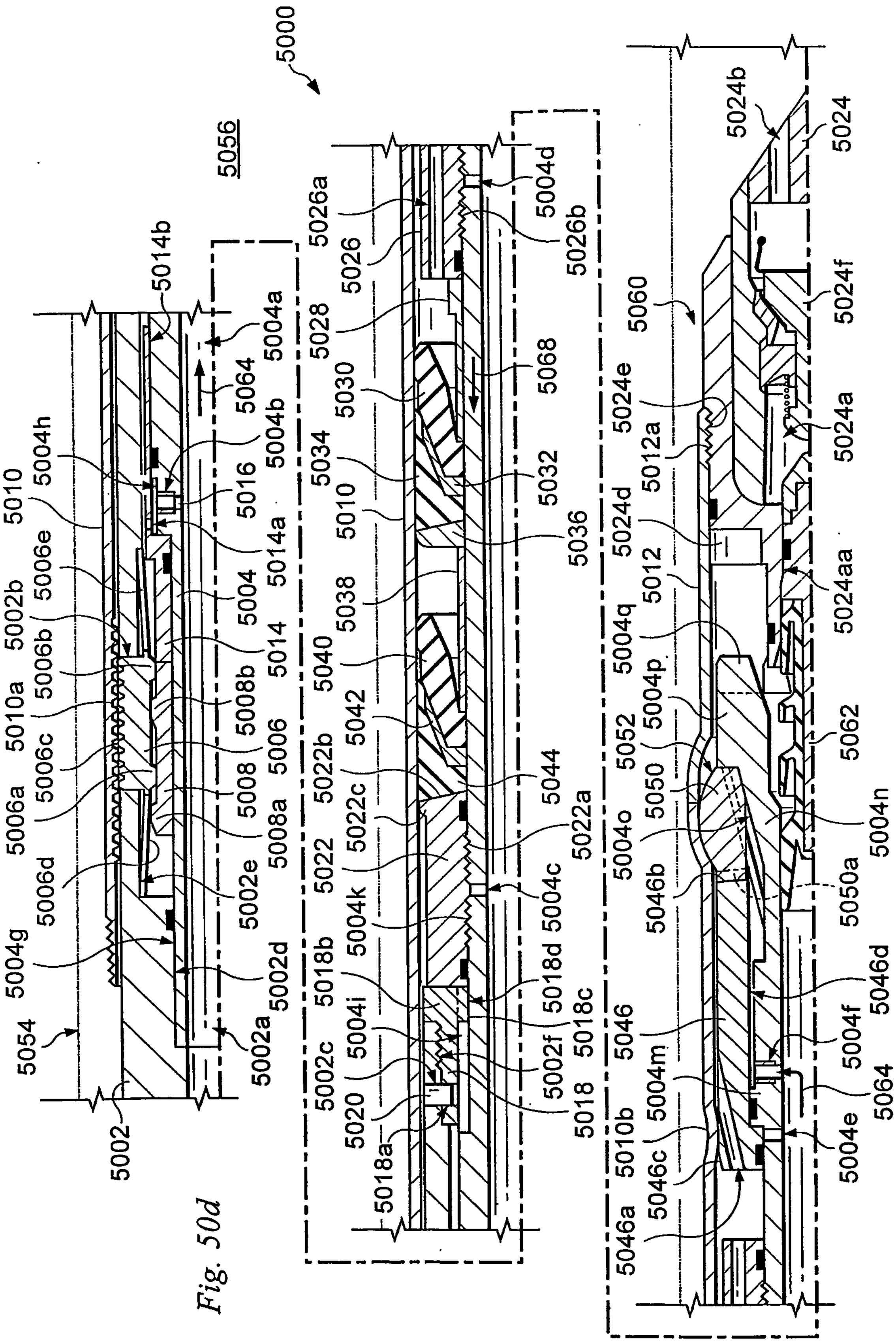
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*Fig. 50d*

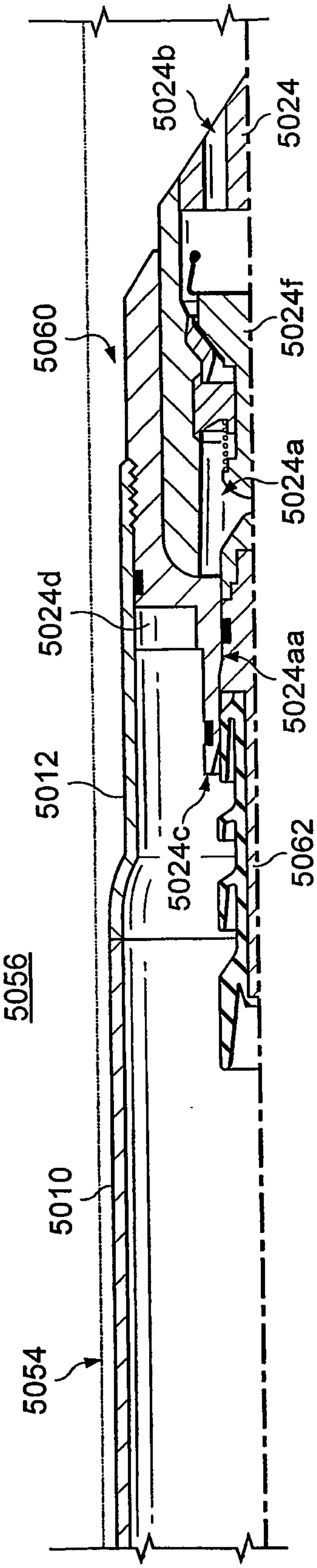
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*Fig. 50e*

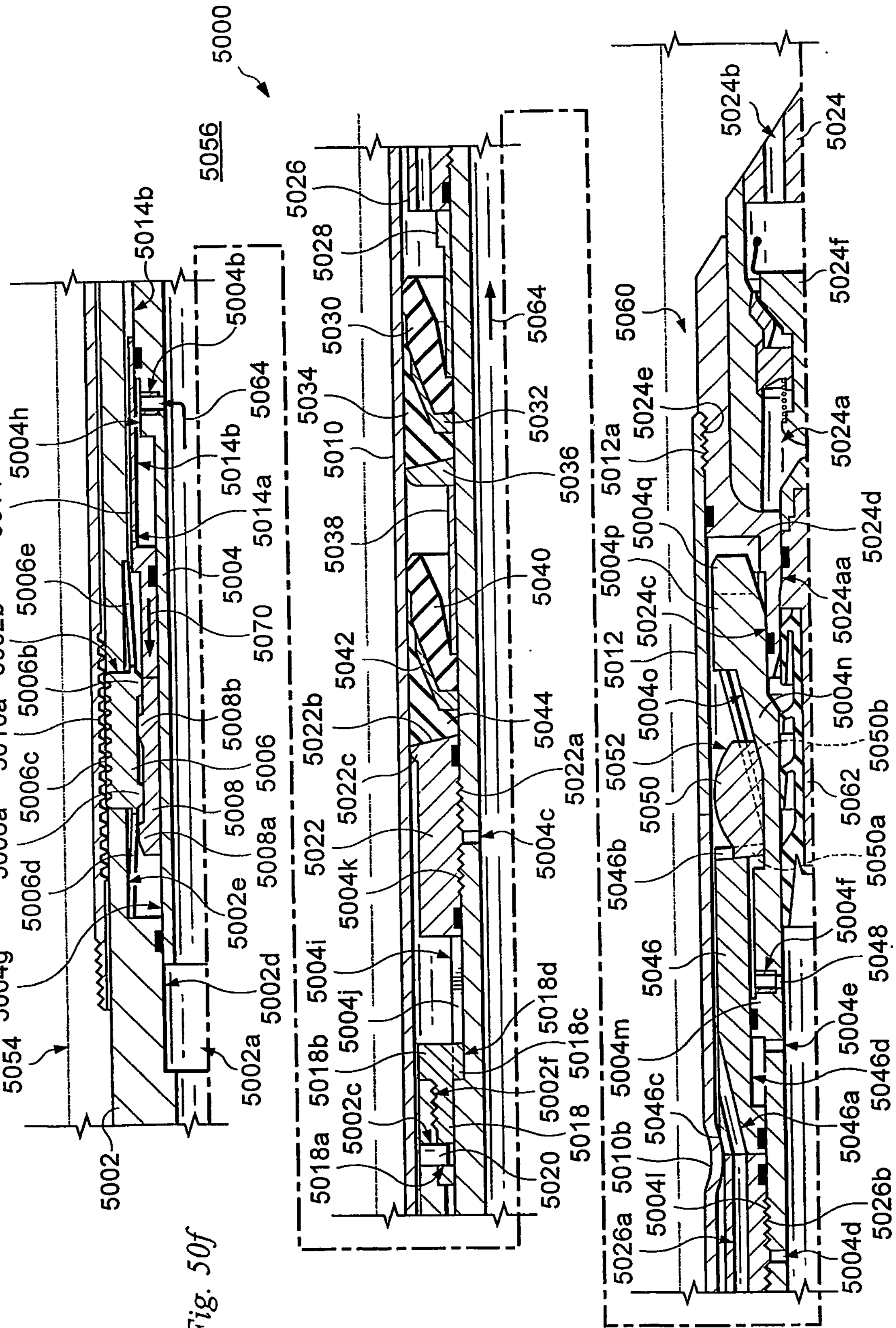
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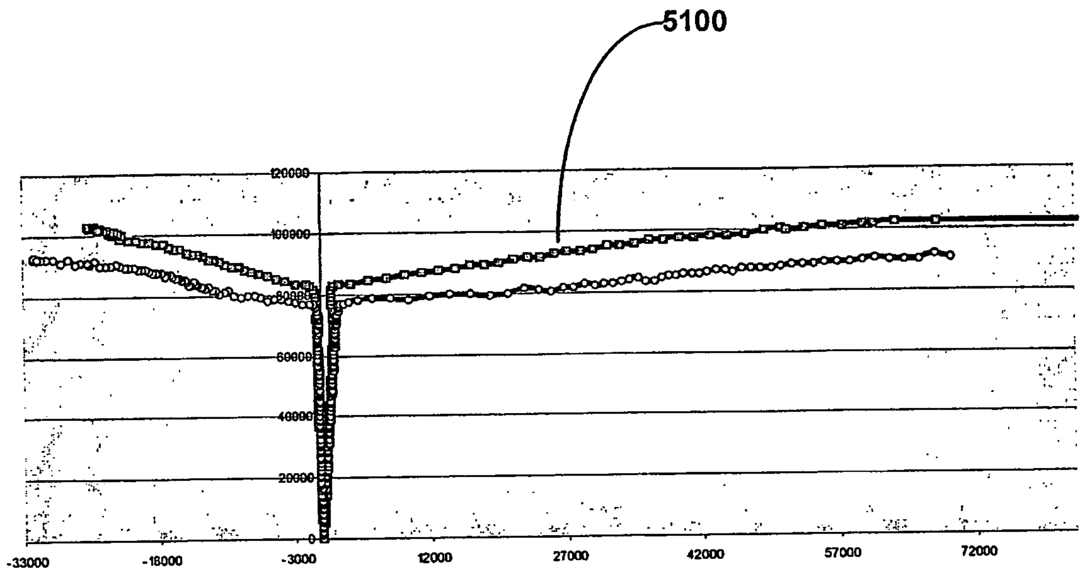
*Fig. 50f*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72000

FIG. 51

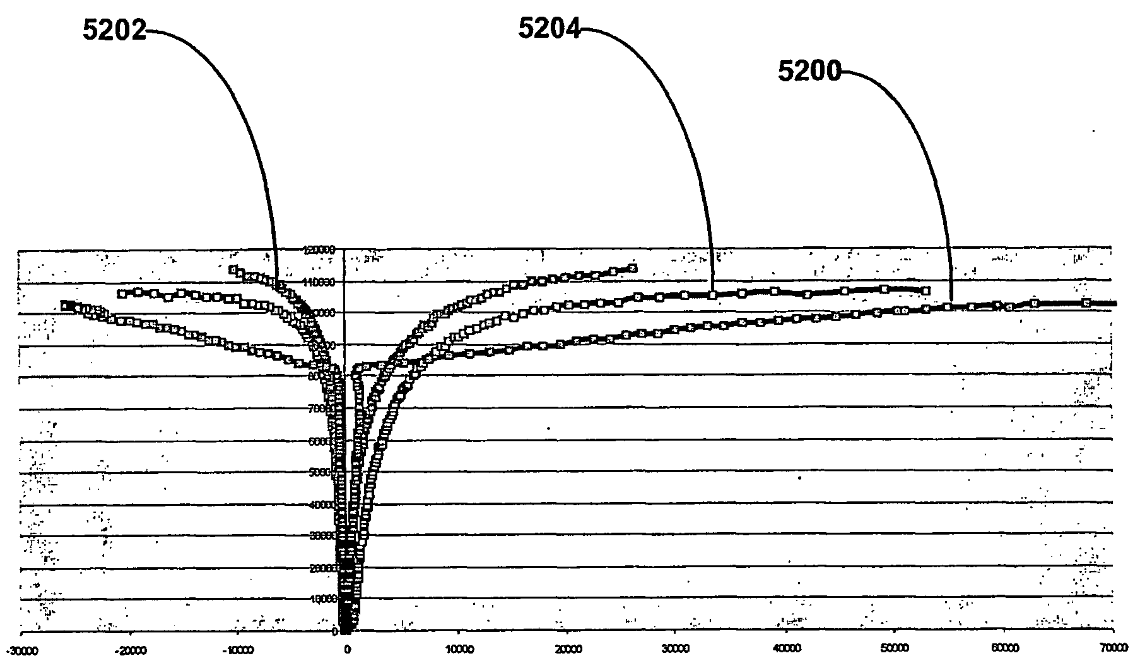
5202
5204
5200
-30000
-20000
-10000
0
10000
20000
30000
40000
50000
60000
70000

FIG. 52

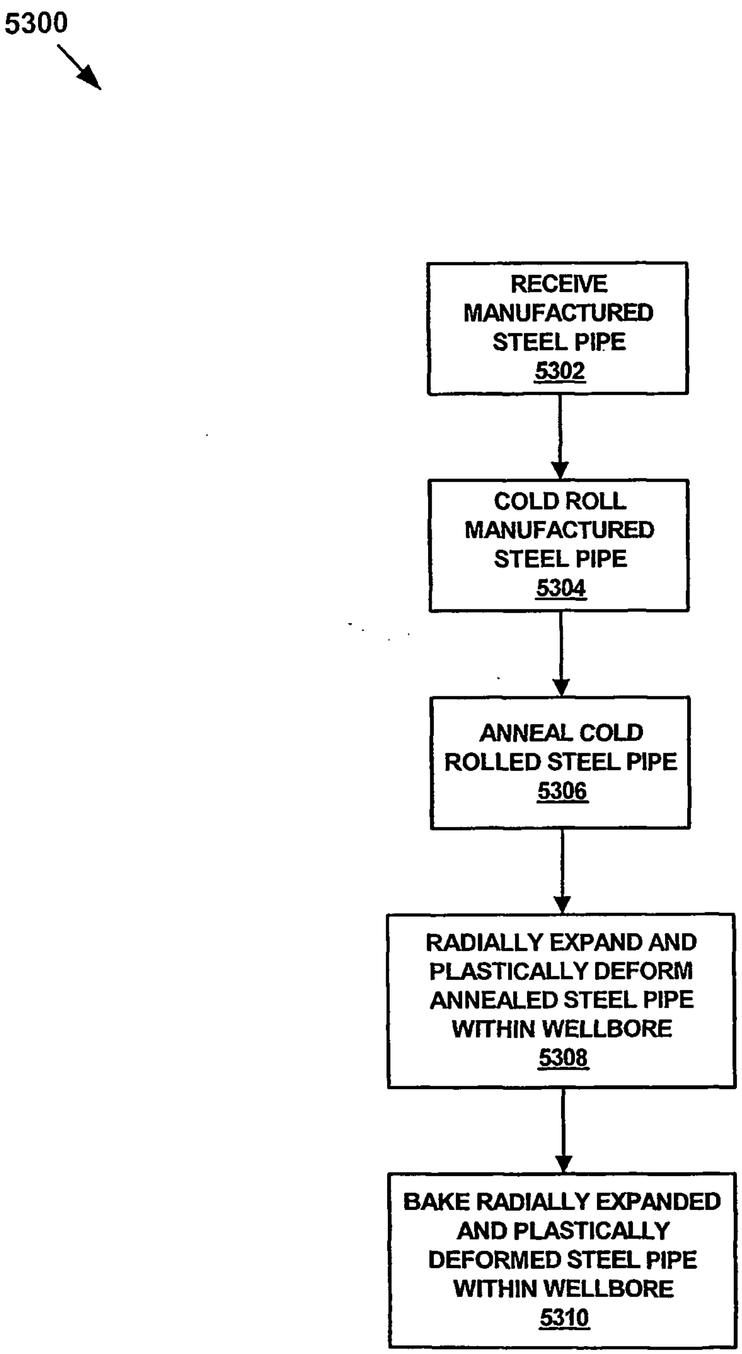
5300
RECEIVE MANUFACTURED STEEL PIPE 5302
COLD ROLL MANUFACTURED STEEL PIPE 5304
ANNEAL COLD ROLLED STEEL PIPE 5306
RADIALLY EXPAND AND PLASTICALLY DEFORM ANNEALED STEEL PIPE WITHIN WELLBORE 5308
BAKE RADIALLY EXPANDED AND PLASTICALLY DEFORMED STEEL PIPE WITHIN WELLBORE 5310

FIG. 53

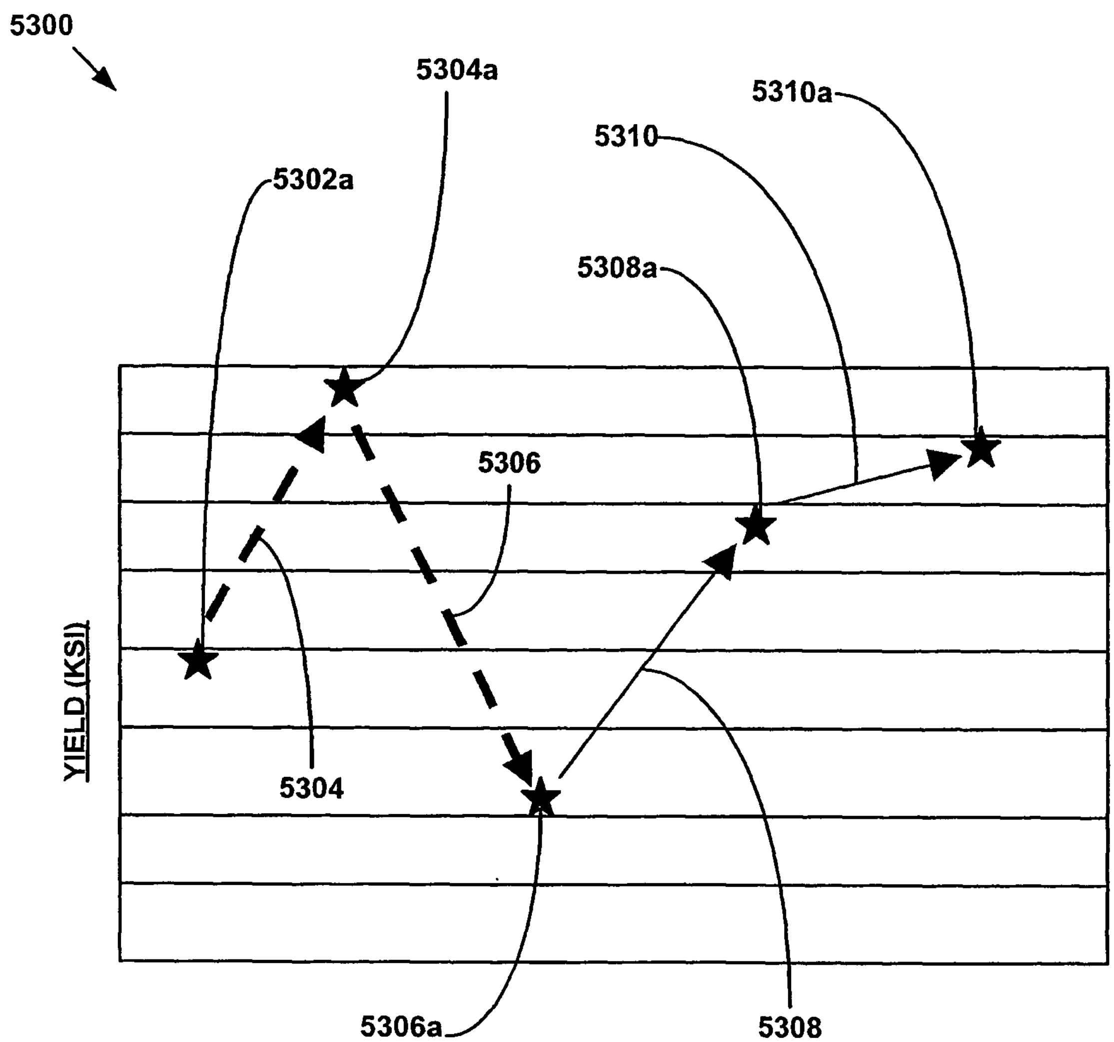
5300
5304a
5310a
5310
5302a
5308a
5306
YIELD (KSI)
5304
5306a
5308

FIG. 54

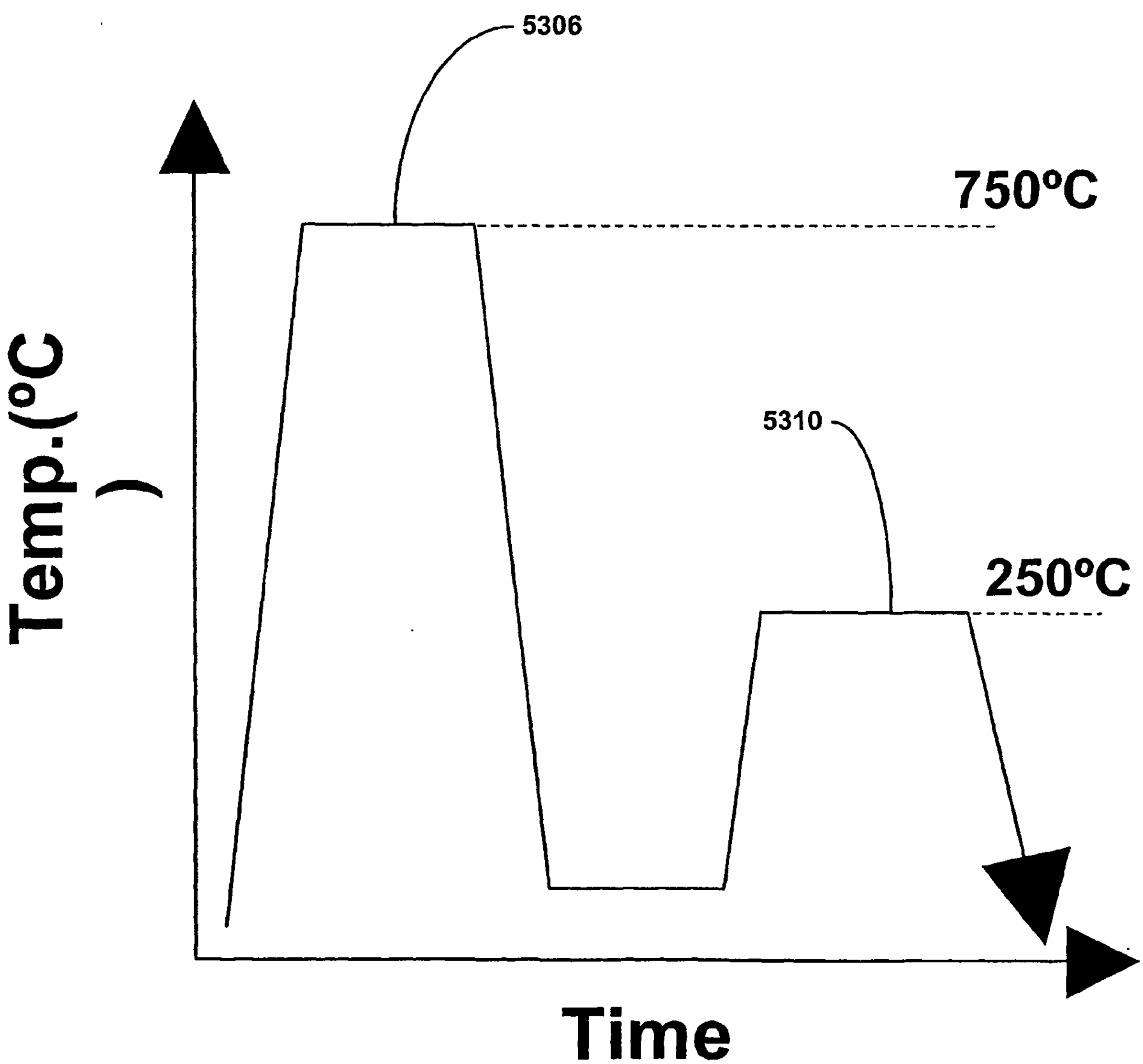


FIG. 55

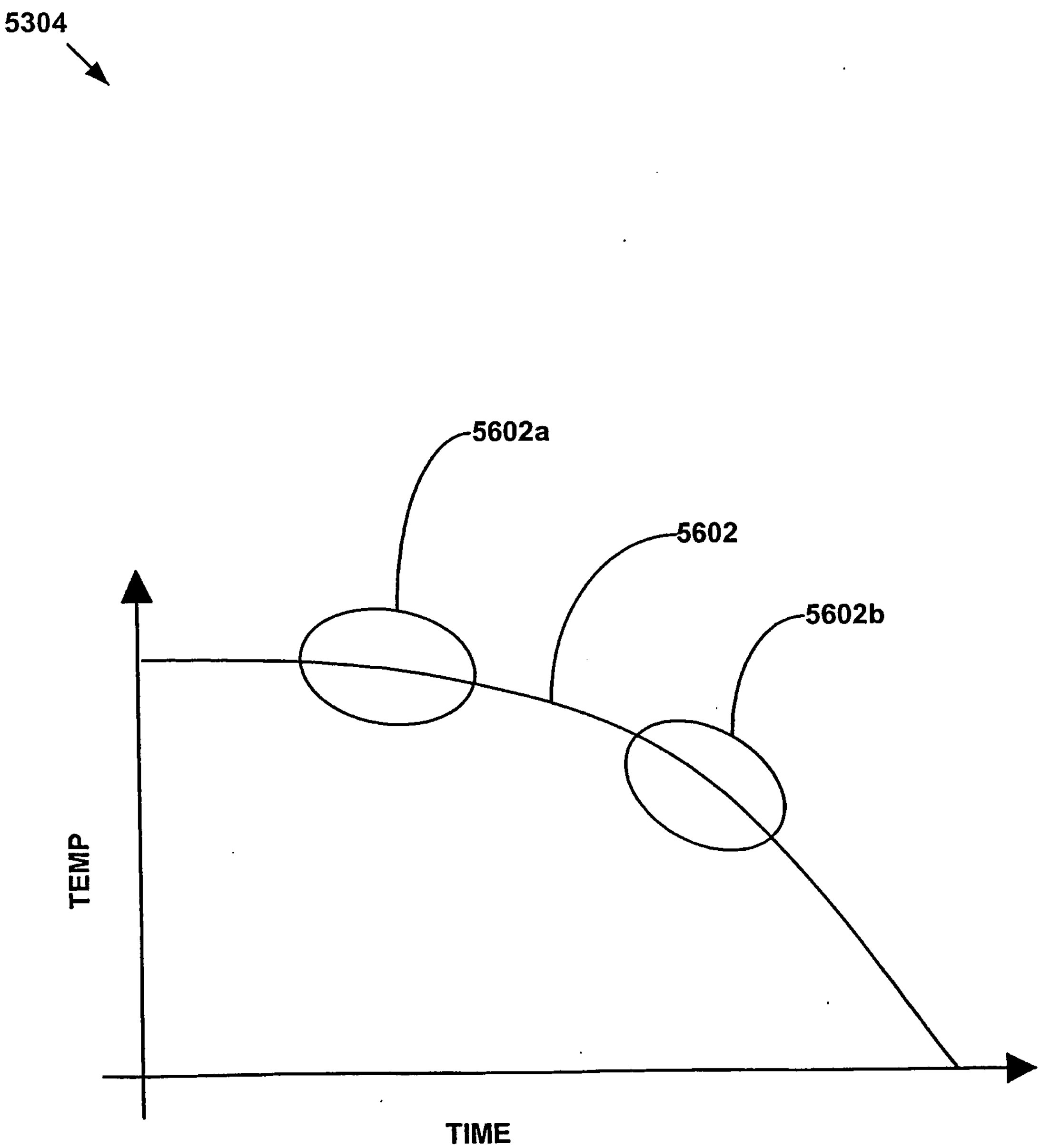


FIG. 56